Vol.2020-MBL-96 No.30
Vol.2020-UBI-67 No.30
Vol.2020-CDS-28 No.30
Vol.2020-ASD-19 No.30
2020/9/30

Personality Based Behavior Change Interventions to Increase UV-B Exposure

YUKA NODA[1,a)] KAZUHIRO IMURA[2]
HIDEAKI NAKAJIMA[3] TADASHI OKOSHI[2] JIN NAKAZAWA[1]

Abstract: In recent years, there has been an increase in the number of people suffering from bone related health issues. This can be attributed to our sedentary lifestyle, which allows us to go for days without getting adequate sunlight. Exposure to sunlight, or UV radiation is often associated with negative images of skin cancer and sun buns; however, adequate UV exposure is important in creating vitamin D, which plays a key role in maintaining the levels of calcium in our bodies. While many studies point out the benefits of exposure to sunlight, existing researches dealing with behavior change tries to promote sun protection behaviors or tries to prevent people from exposing themselves to UV radiation. This poses an alternate threat of bone related health issues towards those who are not getting enough sunlight. In order to motivate people to continue to get adequate sunlight exposure, we will create an application that provides interventions geared toward one's personality, as well as using context aware notifications to allow for behavior change. This system will employ the use of the OCEAN Model to determine the personality types of the users and will attempt to persuade the user to change their behavior with UIs that are designed specifically for those personality types.

Keywords: UV Exposure, Behavior Change, OCEAN Model

1. Introduction

In the world today, the number of people suffering from bone related health issues, such as rickets and osteoporosis, is increasing. From 2009 to 2014, the number of children suffering from rickets have increased by approximately three times, with 12.3 children per 100,000 children suffering from rickets in the year 2014 [1,2]. The cause of these bone related issues can be attributed to the lack of vitamin D. This is due to the fact that vitamin D plays an essential role in maintaining the levels of calcium in our bodies. This in turn creates for stronger bones. However, it is said that approximately 47.7% of the Japanese adults suffer from vitamin D deficiency in the summer, and 82.2% of the adults suffer from vitamin D deficiency in the winter [3]. While seasons do come into play, this overall lack of vitamin D can be attributed to our shift in lifestyle and ideals.

Fig. 1 Ricket Cases from 2009~2014 per 100,000 Japanese Children

Vitamin D is the only nutrient that humans can produce via epidermal exposure to sunlight, or more specifically, UV-B [4]. While there are other ways of producing vitamin D, such as through the consumption of foods containing vitamin D, it is often not enough to accommodate for the lack of UV-B exposure. The use of vitamin D supplements are also available, but the overconsumption of these man-made vitamins has dire effects on one's health. Our sedentary lifestyle combined with a Westernized diet low in vitamin D and a beauty ideal that glorifies white skin, makes it easy for one to suffer from vitamin D deficiency. This, combined with the habitual use of sunscreen and sun protection habits, creates for a population who are afraid or unwilling to expose themselves to adequate sunlight. While there is indeed a risk of getting skin cancer with over exposure to sunlight, it is important to remind people of the benefits of UV-B exposure.

Currently, there are four main ways to measure the UV exposure of a person, with a combination of the use of smartphones and UV sensors [5]. However, most commercialized applications are often designed to limit the sunlight exposure, or to sell skin care products that suits the person's skin type. This type of UI gives a negative connotation to UV exposure and is detrimental in getting people to go outdoors. While this could be beneficial in preventing skin cancer and to promote anti-aging skin, it is not helpful in preventing bone related health issues. Furthermore, the sensors paired with these applications can also be intrusive, with the users having to have to put the device on at all times. The application itself also relies on the use of UV Index, which are helpful in forming the generalized idea of how strong the UV rays are, but not so much in determining how long a person should stay outside to get their fill of UV-B rays.

From these current technological issues, there is a need to develop a smartphone application that can stand alone by itself, and appropriately notify the users of the daily quota to fulfill their daily Vitamin D production, in an understandable way. Due to the seamless integration of smartphones in our lives, it is likely that these smartphone devices will be on the person at all times, removing the unnecessary step of having to have to wear a separate

1 Faculty of Environment and Information Studies, Keio University
a) yuni@ht.sfc.keio.ac.jp
2 Graduate School of Media and Governance, Keio University
3. National Institute for Environmental Studies, Japan

device. This makes the smartphone a great candidate for the device of choice in regard to monitoring behavior change and providing interventions.

The main aspect of our study will be the implementation of the personality-based interventions. With the use of the OCEAN Model, we will provide different UIs geared towards the different personality types. With this, we hope to find the most effective interventions for each of the different personalities.

In recent months, with the spread of the coronavirus, this problem of inadequate sunlight is aggravated by orders to stay indoors. With the limitation placed on each person to stay indoors for the sake of the community, it is likely that there will be more people suffering from vitamin D deficiency in the days to come. Now, more than ever, it is important to remind people of the health benefits of going outdoors (while practicing social distancing).

In section two, of this paper, we will discuss the importance of focusing on both the internal and external factors. In section three, we will introduce the OCEAN model, which we will employ to categorize people and their interventions. In section four, we will discuss the related works that contributes to both behavior change, stages of behavior change, and those that employs the use of the OCEAN model. In section five, we will recap our goal, and in section six, we will solidify our approach. Section seven will elaborate upon the system design. Section eight will discuss future works and experiments that must be conducted. We will conclude our paper in section nine, with a recap on our proposal.

2. Motivation

The challenging aspect of this research is essentially changing the behavior of a person who may not necessarily be motivated to change; however, this idea of changing one's behavior becomes important when applied to their health, whether it be exposure to sunlight or to eat a healthy diet. The applications are countless. In order to intervene and promote a behavior change, we will be focusing on the internal and external factors.

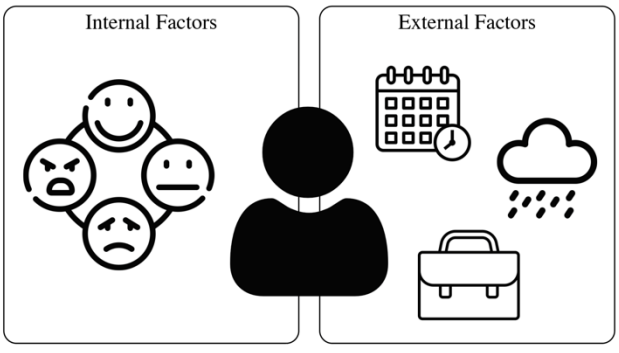


Fig. 2 Internal and External Factors

The internal factors refer to one's personality and how they think. This is essential, for in order to convince people to perform an action, one must know what resonates with their ways of thinking. To determine one's personality types and their ways of thinking, we will be employing the use of the OCEAN model, which is a personality trait theory in the field of psychology.

After the categorization of personalities, we must tackle the external factors. The external factors mainly include the person's contexts. In this case, the context comes in the form of weather and schedule. The reason for considering the external factors when dealing with behavior change is due to our belief that conflicting events or obligations will interfere with behavior change. To combat this, we will be taking into account their schedules and external conflicting situations, in order to better prod them to change their behavior effectively.

3. OCEAN Model

As discussed previously, in order to determine a person's personality, we will be employing the OCEAN Model [6]. The OCEAN Model was first developed to determine the relationship between the academic behaviors and personality. Now, it has been used in various researches with different fields. The OCEAN model is a personality trait model that scores a person on five different categories. The five different categories are openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism, and are measured on a range from 0 to 100, rather than binary. These five categories, while are not enough to describe a person as a whole, provides an insight into the overall personality of a person.

While there are minor fluctuations, the overall personality of a person is said to be stable [7]. Due to this factor, we believe that designing different UIs that speak to each of the different personalities is possible.

4. Related Works

There are many researches conducted on the benefits of UV-B radiation in terms of the science behind the creation of vitamin D [4,8]; however, existing researches conducted on the behavior change aspect in regard to UV-B radiation exposure warns people of the dangers of it and attempts to get people to practice sun protection habits [9]. Because of the lack of research conducted using the OCEAN model to intervene with one's sunbathing habits, we will take a look at the following: researches on behavior change, on the OCEAN model, and on the theoretical models of behavior change stages.

One of the most successful instances of behavior change has to do with the implementation of Pokémon Go. The significant aspect of this service is the use of gamification to motivate behavior change. Gamification is the use of elements of a game applied to other aspects of one's life, such as studying and exercising. With Pokémon Go, there are different motivational factors presented in forms of mini games within the application, which can resonate with different personalities. Studies conducted showed that there was indeed an increase in activity in all ages in both genders through the use of Pokémon Go [10,11]. In particular, they found that the application of Pokémon Go affected those who were initially getting less than the average amount of exercise [10]. This research does acknowledge their limitations, in which the sample collected relied on the ability to afford a device to (1) play the game (smartphones) and (2) keep track of their activity levels (Microsoft Bands). The research was also conducted for a span of 30 days; therefore, they were not able to gather data on the long-term effects of Pokémon Go.

To counter this research, there was a research conducted by Howe, which focused on the long-term effects of Pokémon Go on behavior change [12]. In this research, they found that while there were initial changes in user behavior as a result of the implementation of the game, the activity levels six weeks after the implementation showed that there was no activity level change from prior to the implementation. These researches both point out the role gamification plays in changing one's behavior. While there is a difference in focus on the analyses conducted by both researches, it is without a doubt that both researches do find a behavior change, whether it be an immediate term or a long term one.

The use of gamification is highlighted in Pokémon Go. With various little quests and mini games, it appeals to many different people. We will reference these papers and their discussion on the use of gamification, and attempt to apply this aspect to our system.

Another research of our focus is a research conducted by Courneya, K.S. [13] In this research they attempt to find the correlation between the OCEAN model personalities and the different exercise categories that suits each of the personalities, as well as different motivational factors that may resonate with each of the personality types. In this, they conclude that extraversion and conscientiousness are positively related to exercise behavior, whereas neuroticism is negatively correlated. They conduct the evaluation through the use of regression to find the correlation between personality types and the different level of exercises and motivation factors that works with each of the types. The motivational factors include one's health, appearance, weight, social, stress, and enjoyment. While they may have found a correlation, their correlational values seemed quite low, indicating a low correlation if any. From this research, we take away from it the possibility of a negative correlation between a specific personality type vs physical activity. While our research is focused on getting the users to go outside rather than to perform a physical activity, we will note this correlation for reference. While their research was conducted through the use of Amazon Mechanical Turk, in our research we will be attempting to conduct an actual experimentation to determine the correlation.

Similar to Courneya's research, Rhodes, R.E. conducts a meta-analysis on the correlation between physical activity and personality types [14]. While they do focus on other personality theories such as Cattell's 16 primary factors, we will focus on the analysis they conducted on the OCEAN model. In this, they state the lack of correlation between physical activity and Openness to Experience and Agreeableness. They also states a positive correlation between Extraversion and Conscientiousness. Similar to Courneya, they found that neuroticism is indeed negatively correlated to physical activity, but only by a small margin. These correlations are also important to note and to implement in our study.

While personality types seem to have a correlation to physical activity, there may also be the existence of different intrapersonal stages that may exist with behavior change. In a research by Marcus B.H., he established the relationship between different stages of behavior change and self-efficacy. Self-efficacy is the measure of one's belief that he or she can accomplish a task or attain a specific goal. In this, he surveyed government and hospital employees and attained information on their stages of exercise habits. These stages were split into precontemplation, contemplation, preparation, action, maintenance, and relapse. These stages range from people who have not started exercising to those who have exercised in the past. As a result of his research, he found that people at the precontemplation stage have a lower self-efficacy than those who were at the maintenance stage. For this, we will measure the self-efficacy of each users at every week in our study.

While the applications of these researches may differ from our goal, these researches serve as a baseline for our research and provides insightful points. For these reasons, we have introduced these researches related to behavior change and the use of the OCEAN model.

5. Goals

With all the researches that are available, the goal of this study is to create a platform that supplements inadequate vitamin D via subject/personality-based interventions, through the focus of both internal and external factors. In other words, we will attempt to create a persuasive intervention for each of the personalities given, as well as taking into account the person's schedules and contexts. This focus on both the internal and the external may lead us closer to discovering a persuasive behavior change method that may resonate with different personalities.

6. Approach

6.1 Personality Based Interventions

In order to achieve our goal, we will have three different approaches. The first approach is to categorize people into different personality types, using the OCEAN model. The OCEAN model, also known as CANOE model or the big five model of psychology, categorizes people into different personality groups based on a range, rather than binary categorizations. This allows for a person to have five different scores ranging from zero to 100 for each of the OCEAN personality to see what kind of a person they are. By determining their scores for each of the OCEAN personalities, we will provide five different interfaces to see which one works best in attempting to motivate people to change their behavior.

For our study, we will be using five different user interfaces that correlates with each of the different personality types. This will allow us to see if the screens that we have designed for people with a high categorical score are actually effective for those people. Each of the UIs geared towards each of the personality types are as follows.

People with a high score on the Openness to Experience scale are said to prefer variety over routine. In our research, we will be alerting them with different options and quests that they can fulfill to meet their daily quota. For instance, instead of giving a set time for the users to go outside, we might have other options, such as walking to a specific destination, that would also take them the same amount of time to meet their daily vitamin D quota. By specifying a location for them to visit, we could play towards their openness to experiencing new locations. Another example would

be to have them check in at different times of the day to step outside for 5 minutes. By having a various routine for this type, we could encourage people with high scores on the Openness to experience scale to change their behavior and keep them motivated.

People who have a high score on the Conscientiousness scale are those who are self-disciplined. For this type, we will be allowing them to choose their own goal out of three options that all meets the daily needs. For instance, the users will be given an option of stepping outside from 15 to 30 minutes, all of which meets the daily quota of Vitamin D. By having the people who score high on the Conscientiousness scale to choose their own goals, we will be able to encourage them to stick to it more than a goal that another might set for them.

People who rank high on the extroversion scale are those who often likes the company of others and are attention seeking. To suit their personality types, we will be designing a ranking system that will allow the users to compare themselves to other users in the group. We will rank them by the amount of time that they have stayed outside, with a limitation on the maximum number of minutes to correlate to the healthy amount of sunshine exposure.

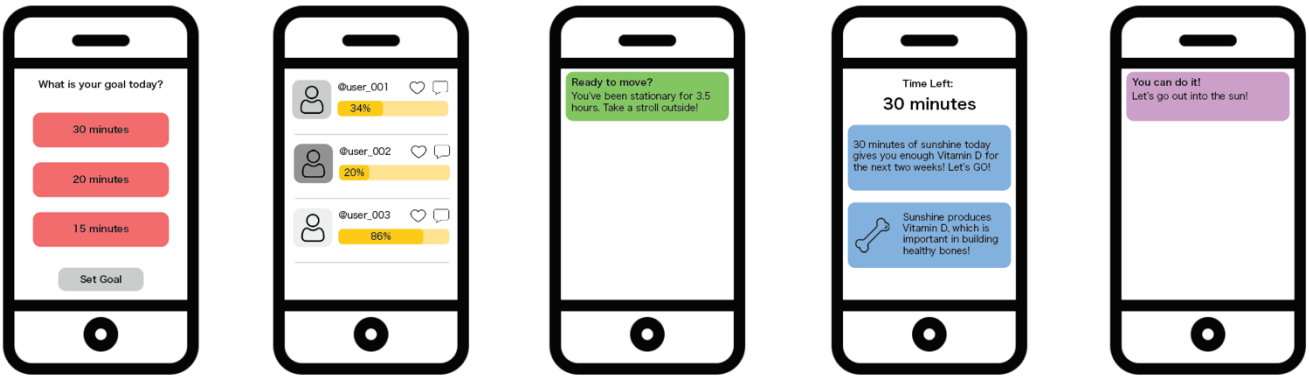


Fig. 3 Sample UIs

This will allow these people to interact with other people, while simultaneously aim to beat the other users in terms of rank.

People who score high on agreeableness are said to be those who likes to be helpful. For these people, we will design an interactive interface, where they will be able to like and comment on other users' statuses. This will allow these people to interact and encourage fellow users to reach their goals, which in turn, may help them accomplish their own daily quotas.

People who score high on the Neuroticism scale are said to be those who are vulnerable to stress. In order to motivate these people to meet their goals, we will attempt to use positive notes and messages to try to convince them to go outside. Their notifications will be overall positive and will focus on the relaxation techniques that one can use while being outdoors.

These five different user interfaces geared toward the different personality types deals with the internal factors that may affect one's motivation to change. For the second approach, we will be taking a look at the information that could be provided to change one's behavior.

6.2 Feedback

As our second approach, we will be feedbacking to the users the amount of time they have left to fulfil their daily quota. While feedbacking information of Vitamin D production and the UV Index gives them a sort of a measure, it is often not a measure that people are used to, leaving people confused as to their next form of action. To inform people of the time left to fulfill the data, we will be using the UV-B data from a UV sensor, and converting it to the amount of vitamin D that the skin will produce, using the sensor and the equation provided by the National Institute for Environmental Studies, Japan [17].

$$QD = qe \cdot Stype \cdot Sder \cdot tex \cdot IVD$$

QD stands for the amount of vitamin D that the human skin is capable of producing. qe, $Stype$, $Sder$, and tex stands for the production rate of vitamin D via UV exposure, effect of skin types, exposed skin area, and sun exposure time respectively. The IVD stands for the amount of UV radiation that is available at a given time. By solving for tex, we are given the amount of time it takes to produce an adequate level of vitamin D.

From this amount of vitamin D that the humans could produce at the time, we will calculate the amount of time that the person has left to get their daily vitamin by calculating it from the accepted daily quota. While the areas in which the sensors are located are limited, for the purposes of our study, we will be looking at not how accurate the time quota data is, but rather how these types of information and UIs affect the person's behavior. By displaying this information, we will be able to provide the users with information that they could actually use to determine their next course of action.

6.3 Context Aware Notification

Our third approach will be using context aware notification timing. This will account for the external factors, such as a person's schedule, which may infringe upon their ability to go outside. We will obtain the persons' schedule from their calendar within their smartphones and notify them when a specific meeting ends. We will also get their gyro data and notify them if (1) they have been stationary for over an hour, or (2) they have just begun to move. This indicates that the person is either working for a while, and is in need of a stretch, or they have decided to take a stretch, which is a good time to notify people to get outside.

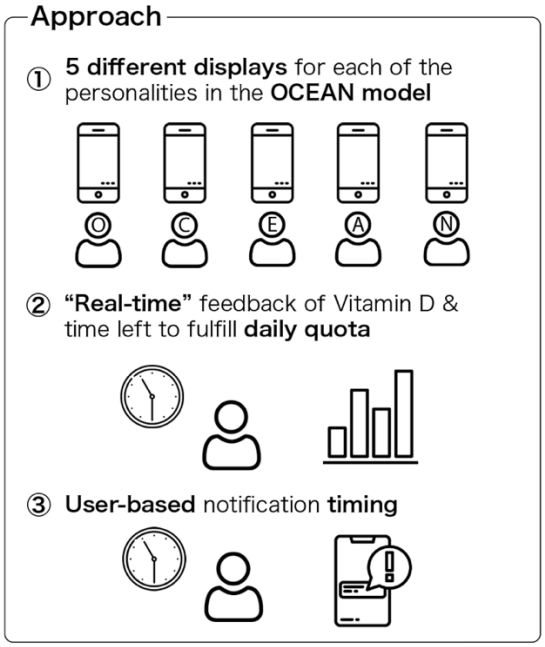


Fig. 4 Approach Diagram

One of the key facts that would come into play is the reduction of the burden that we place on the users in using this application. One the burdens that could exist is the manual input of data by the users on whether they are indoors or outdoors. It is true that we can collect data by having the users press a button every time they step outdoors; however, this action could pose a barrier in going outside, and users may forget to press the button due to the fact that it would be going outside their normal habitual patterns. In order to reduce this burden, we conducted an experiment that attempted to use only the ambient noise data to determine whether the user was indoors or outdoors. With this preliminary experimentation, we found that with champion data, it would hypothetically be possible to determine the user location with the use of machine learning; however, with the updated limitations on the iOS13 to gather ambient noise in the background and the time it would take for the learning to be conducted, it may not be a viable solution.

While there are various combinations of devices that help with the determination of indoor/outdoor detection, we will attempt to determine whether the user is indoors or outdoors solely with the use of the smartphone. For this, we will rely on the GPS, WIFI connection, along with activity recognition. Due to the fact that it is currently not possible to get the GPS strength via the iPhone, we will focus on the accuracy of the GPS, along with the strength of the WIFI connection. Activity recognition comes into play when the user is stationary for a given set of time, which may indicate that the user is indoors. There are limitations with this method, such as the use of the pocket WIFI that interferes with the baseline signal strength that is imagined for the outdoor WIFI connection.

7. VitCog System

Our system, VitCog, as discussed in the approach is designed as an iOS application, targeted at iOS 13.0 and above. The user will be able to use the application on their own timing, as well as notification prods to show their current standing with UV exposure.

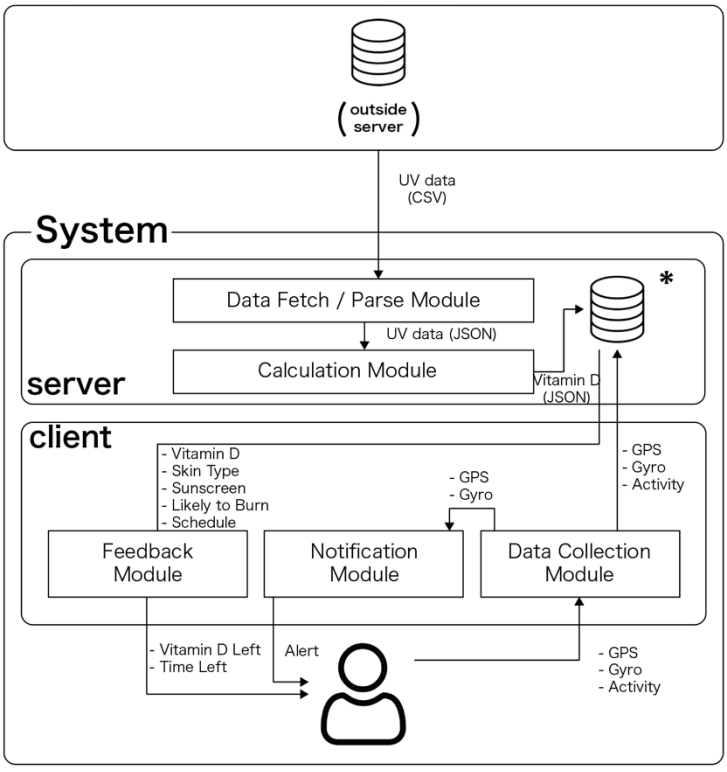


Fig. 5 System Architecture

7.1. Uses

The users will be allowed to use the application on their own timing; however, the system will notify the users based on the users' behavioral patterns to prompt them to go outdoors. The use-case scenario would be that (1) the user is indoors (2) the user is notified by the app to go outside (3) the user will go outside for a given amount of time to meet their daily vitamin D quota (4) the users will receive feedback of the amount of time left to fulfill their daily quota. By having this user flow, we hope to persuade people to continue to go outside to get adequate UVB exposure.

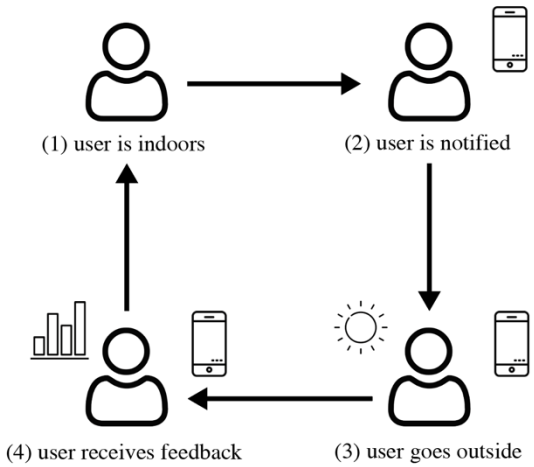


Fig. 6 Use Flow Diagram

7.2. Application UI

The application will have five different user interfaces, all geared toward a specific characteristic in the OCEAN model. For those with a high score on Openness to Experience, who prefers variety over routine, we will provide a variety of quests to make them to go outside. For those with high scores on Conscientiousness, we will allow the users to choose their own goals, due to their self-disciplined nature. For those with high scores on Extraversion, who prefers to have the company of others, and are attention seeking, we will have a ranking system for them to compete against each other. For those with high scores on Agreeableness, which are helpful people, we will allow them to encourage other users via the use of a like or a comment function. For those with high scores on Neuroticism, who are vulnerable to stress, we will provide them with positive feedback to encourage them to change their behavior.

7.3 Feedback Module

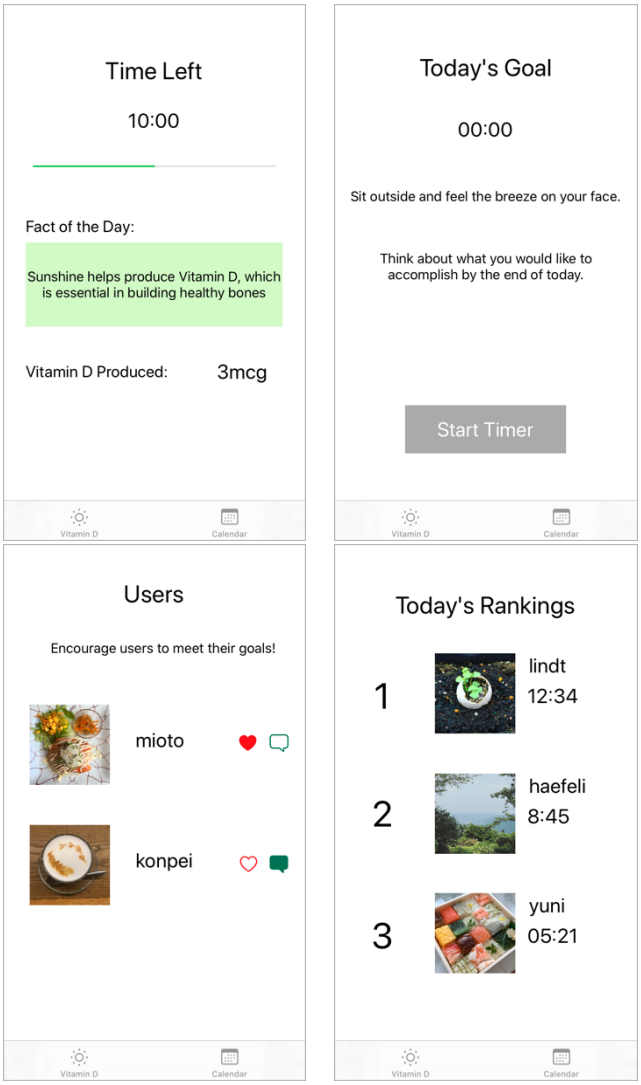
Based on each of the five different personality types, the way the information is presented will be different; however, to counter the changes in behavior which could be derived from the information provided, we will essentially feedback to them the same types of information. In other words, we will be presenting the information regarding their overall daily quota of Vitamin D to all five of the personality types.

7.4 Notification Module

In order to counteract the external factors that could affect one's decision to go outside, such as the user's schedule, we will notify the people based on their schedule and recent movement. For instance, the users will be notified when they have nothing in their schedule, as compared to when they have a meeting. Users may also be notified if they are sitting down for a long time, or at the point in time where they start moving.

8. Implementation

Based on these approaches and system architecture, we have implemented the proposed system in the form of an iOS application as shown in the following figures.



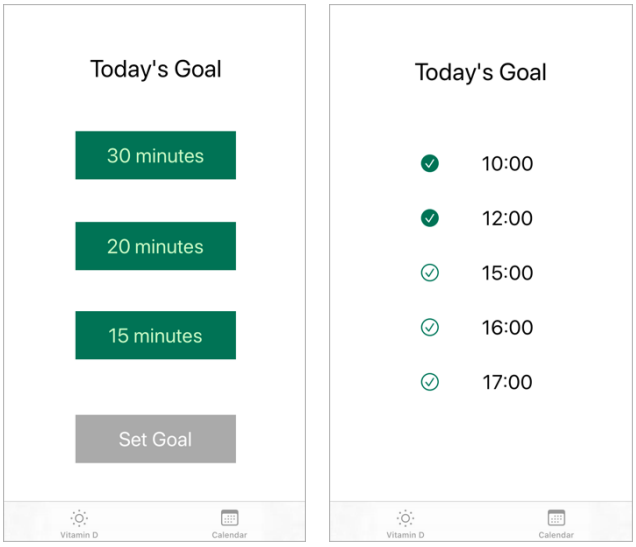


Fig. 7 Implementation of the iOS Application

9. Future Experimentation and Evaluation

To find the effectiveness of our system, we will be conducting an experiment, assessing both our system, and its effect on the users. The experiment will last a span of six weeks, with a sample user size of 50. It is noted that there is a difference in the length of the time it takes for habits to develop [16]; however, we will focus on the preliminary changes in behavior with the introduction of the system. In the first week of the study, we will collect the baseline data for each of the users, on their normal activity patterns prior to any interventions. At this point, we will also collect information on their habitual use of sunscreen, their skin type, their self-efficacy scores, and their OCEAN model scores. In the subsequent five weeks, we will assess the effect of each of the personality-based UIs on each of the individual users. During the five weeks, we will be collecting the data on the user's schedule via the calendar within the smartphone, GPS, WIFI connectivity, human activity, and gyroscope. We will also measure the users' self-efficacy and OCEAN Model scores on a weekly basis.

In order to evaluate the effectiveness of our system, we will focus on the immediate and the short-term effects in regard to our six weeks. In order to determine the immediate effect that our system had on behavior change, we will look at the changes in the user movement right after a notification was sent, and after the user opens the application. In order to determine the short-term effects, we will take a look at the percentage increase in outdoor activities, the number of days the vitamin D goals were met.

10. Conclusion

Behavior change is an integral part of a person's life in which it allows for the change of the behavior to a healthier or better pattern. However, changes in behaviors and habits often takes a long time and a lot of effort. Without a good intervention, it is hard to stick to a goal, even if the person knows how much benefits the person can reap from sticking to the goal. For this, our research will attempt to find a method that resonates with each of the personalities given in the OCEAN model.

Exposure to UV radiation, while may have negative connotations, are beneficial in minor doses. The challenge of this system and research would be to attempt to change the people's behavior on a topic or an activity that the user has a negative image on. These activities, while can seem tedious and time-consuming, can have overall positive effects on one's health and lifestyle.

As part of our future works, we will conduct the experiment on a sample size of 50 to determine whether there was an affect in using our system. With the results of this experiment, we would further be able to improve our system and conduct more experiments to collect and analyze the data.

Acknowledgement

This work was supported by JST CREST Grant Number JPMJCR19A4 Japan.

Reference

[1]Itoh, Mitsuko et al. "Vitamin D-Deficient Rickets in Japan." Global pediatric health vol. 4 2333794X17711342. 1 Jun. 2017, doi:10.1177/2333794X17711342

[2]Miyako, Kenichi et al. "Vitamin D deficiency rickets caused by improper lifestyle in Japanese children." Pediatrics international : official journal of the Japan Pediatric Society vol. 47,2 (2005): 142-6. doi:10.1111/j.1442-200x.2005.02041.x

[3]Asakura, Keiko et al. "Vitamin D Status in Japanese Adults: Relationship of Serum 25-Hydroxyvitamin D with Simultaneously Measured Dietary Vitamin D Intake and Ultraviolet Ray Exposure." *Nutrients* vol. 12,3 743. 11 Mar. 2020, doi:10.3390/nu12030743

[4]Nair, Rathish, and Arun Maseeh. "Vitamin D: The "sunshine" vitamin." *Journal of pharmacology & pharmacotherapeutics* vol. 3,2 (2012): 118-26. doi:10.4103/0976-500X.95506

[5]Turner, Joanna & Igoe, Damien & Parisi, Alfio & McGonigle, Andrew & Amar, Abdurazaq & Wainwright, Lisa. (2020). A review on the ability of smartphones to detect ultraviolet (UV) radiation and their potential to be used in UV research and for public education purposes. Science of The Total Environment. 706. 135873. 10.1016/j.scitotenv.2019.135873.

[6]Costa, Paul & McCrae, Robert. (2012). The Five-Factor Model, Five-Factor Theory, and Interpersonal Psychology. Handbook of Interpersonal Psychology: Theory, Research, Assessment, and Therapeutic Interventions. 91-104. 10.1002/9781118001868.ch6.

[7]Cobb-Clark, Deborah & Schurer, Stefanie. (2011). The Stability of Big-Five Personality Traits. Economics Letters. 115. 10.2139/ssrn.1919414.

[8]Tavera-Mendoza, Luz E., and John H. White. "Cell Defenses and the Sunshine Vitamin." *Scientific American*, vol. 297, no. 5, 2007, pp. 6272. *JSTOR*, www.jstor.org/stable/26069544. Accessed 4 Sept. 2020.

[9]McClendon, B T, and S Prentice-Dunn. "Reducing skin cancer risk: an intervention based on protection motivation theory." Journal of health psychology vol. 6,3 (2001): 321-8. doi:10.1177/135910530100600305

[10]Althoff, Tim et al. "Influence of Pokémon Go on Physical Activity: Study and Implications." Journal of medical Internet research vol. 18,12 e315. 6 Dec. 2016, doi:10.2196/jmir.6759

[11]Nigg, Claudio R et al. "Pokémon GO May Increase Physical Activity and Decrease Sedentary Behaviors." *American journal of public health* vol. 107,1 (2017): 37-38. doi:10.2105/AJPH.2016.303532

[12]Howe, Katherine & Suharlim, Christian & Ueda, Peter & Howe, Daniel & Kawachi, Ichiro & Rimm, Eric. (2016). Gotta catch'em all!

Pokémon GO and physical activity among young adults: Difference in differences study. The BMJ. 355. 10.1136/bmj.i6270.
[13]Courneya, K.S., Hellsten, L.A.M.: Personality correlates of exercise behavior, motives, barriers and preferences: An application of the five-factor model. Personality Indiv. Differ. 24(5), 625-633 (1998)
[14]Rhodes, R E, and N E I Smith. “Personality correlates of physical activity: a review and meta-analysis.” British journal of sports medicine vol. 40,12 (2006): 958-65. doi:10.1136/bjsm.2006.028860
[15]Marcus BH, Selby VC, Niaura RS, Rossi JS. Self-efficacy and the stages of exercise behavior change. Res Q Exerc Sport. 1992;63(1):60-66. doi:10.1080/02701367.1992.10607557
[16]Lally, Phillippa & Jaarsveld, Cornelia & Potts, Henry & Wardle, Jane. (2010). How are habits formed: Modeling habit formation in the real world. European Journal of Social Psychology. 40. 10.1002/ejsp.674.
[17]Equation provided by the National Institute for Environmental Studies, Japan. “http://db.cger.nies.go.jp/dataset/uv_vitaminD/ja/exposition.html#exposition03”
[18]Icon made by Pixel perfect from www.flaticon.com