Using Idle Moments to Record Your Health via Mobile Applications

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ABSTRACT

As *smart* mobile phones permeate society, so too does the opportunity to use these technologies to unobtrusively capture patterns of daily life and interact with people in situ. The ability to record facets of daily life has given rise to the notion of the *quantified self*; researchers operating at the intersection of computer and social science are now seeking to understand how these mobiles' data can aide the design of health interventions and inform future psychological and social science research.

However, current systems are not fully effortless: they require users to interrupt their activities in order to initiate the recording, annotation, or journaling of their experiences. Suitably seeking users' attention and incentivising them to engage with, for example, health applications, continues to be a main obstacle to the adoption of these services. In this work, we describe the design of a new application that seeks user feedback about their gastrointestinal health in an *idle* moment: when the user is sitting on the toilet. We describe the application's design, the health insights it provides (and, particularly, why it is not designed as a diagnostic tool), as well as early data that the system has collected. We close by discussing the opportunity that idle moments present for future health intervention applications.

Categories and Subject Descriptors

H.5 [**Information Interfaces and Presentation**]: General; J.3 [**Computer Applications**]: Life and Medical Sciences

General Terms

Design, Human Factors

Keywords

Health, Android Application

1. INTRODUCTION

In recent years, the sale of mobile devices has exceeded that of personal computers [1]. As they advance, they have also become items that we keep within arms length throughout over 75% of the day [2], and increasingly contain powerful sensors that can measure our activities and expose how we interact with each other [3]. Moreover, by ubiquitously connecting us to the web at all times, mobile phones have become the technological bridge between the online and offline worlds: they allow us to query the web about what is physically around us [4], participate in social media while on the go [5], and access systems that were historically limited to the desktop environment.

There are two notable trends that are enabled by mobile systems. First, mobile phone users are now able to *collect* data about various aspects of their life: these behaviours are now referred to under the *quantified self*[1] pseudonym. On the other hand, users are also able to *contribute* to data repositories via their phones: a behaviour that is shared by both the *crowd sourcing* and *participatory sensing* domains [6, 7]. In other words, mobile systems are becoming a bi-directional medium for data creation and exchange, which makes them perfect candidates for delivering tailored information or behavioural interventions [8]. Both of these trends, however, rely on interrupting the user in order to interact with the application or initiate the recording, annotation, sensing, or journaling of their experiences: a notable challenge in both domains is how to design these systems to enable collection of data while minimising the strain and interruptions that users must face.

The technological approach to this problem would be to design means to detect or predict that users can be interrupted. However, in this work we posit that the shifting social norms around mobile phone usage are creating contexts where applications that do not need to be designed around interrupting the user can be deployed. In the following, we describe one such scenario (Section 2): the use of smartphones inside lavatories, and how this can be related to users' health. We then describe an application that was built to educate and profile users' health (Section 3) and report on initial aggregate data that the system has collected (Section 4). Finally, we close by discussing the dangers that arise, both from applications that have the potential to becoming implicit diagnostic tools and the implications of creating applications that are designed for users' idle times (Section 5). We close with future plans for the application (Section 6).

[1]http://quantifiedself.com/

1.1 Related Work

Mobile systems generate and expose an invaluable mixture of data that contains geographic and mobility information [5], as individual mobile phones pair with cell towers, and people interact telephonically or participate in social media. They also provide accessible interfaces for people to answer questionnaires and input data while in a particular context [9], and receive proactive personalised recommendations [10]. The range of applications for this data is immense and relates to both large-scale patterns and individual's preferences. Mobile phone data has appeared in the recent literature as a means to access and measure the large-scale patterns of populations' mobility [11]. Call detail records—which reflect the network structure of the residents of a country—have also been shown to strongly correlate with neighbourhood's well-being in the United Kingdom [12]. At the same time, mobile phone records have been shown to reflect the user's personal (location-related) preferences, habits and tastes [13]. There is also a rising interest in using technology to deliver health-related interventions. For example, there are novel mobile systems for social psychology research [14], as well as web-based systems like LifeGuide [15] that have been applied to a host of health scenarios (e.g. managing irritable bowel syndrome [16]); the system that we present in the following section draws from this domain.

2. APPLICATION SCENARIO

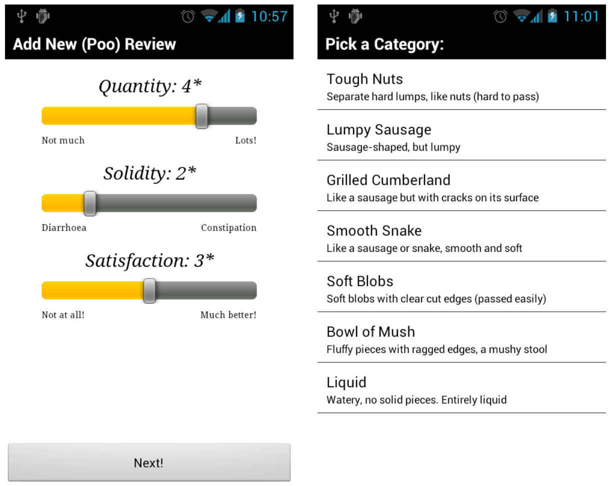
We began by seeking a situation where users may be *idle* (i.e., not otherwise engaged in a critical attention-requiring activity, like driving) and may turn to their phone: one such situation is when people are in the lavatory. We assume that this would be a situation where (a) users are alone *with* their mobile phones and (b) are there for an activity that directly reflects their health.

There is evidence that taking phones into the lavatory is a behaviour that has been widely adopted. In January 2012, the New York Times reported[2] on the "rise of the toilet texter:" the article discussed the results of a survey (by a marketing agency) about the extent that people use their mobile phone while on the toilet. Of the $1,000$ survey respondents, 75% admitted to using their mobile phone while on the toilet; the figure was as high as 91% for those who are between the ages of 28 and 35 and 47% for those above 65. The survey included a variety of other facts (e.g., 63% take calls); most notably, 25% of respondents claimed to never go to the lavatory without their phone.

Of course, habits relating to and experiences of going to the lavatory reflect on a person's well-being and quality of life [16]. There is a vast range of disorders and illnesses that will negatively affect a person's regularity and experience in the lavatory: ranging from diarrhoea and constipation, to irritable bowel syndrome, food poisoning, and bowel cancer. However, this is a domain where measuring patterns of activity, educating people, and delivering tailored information remains elusive. For example, an Internet-based intervention [17]—that seeks to help users understand, reflect, and set lifestyle goals to positively influence any minor bowel problems—ask participants to recall their habits rather than measure them, and lack a way of allowing users to see if they have met their goals. Furthermore, educating the public about signs of ill-health has also become a prominent issue: the rise of bowel cancer has led to a series of extensive awareness campaigns led by Cancer Research UK [18] as well as the UK National Health Service[3] that urge people to seek medical attention if they recognise a set of base symptoms in their toilet-going habits (namely, blood in the stool or over three weeks of loose stool), and to overcome the social stigma of openly discussing any concerns.

The two main conclusions from the above is that there are (a) ample educational and health issues that revolve around people's toilet-going habits and (b) people take their mobile phones into the lavatory to pass the time; it is thus an ideal *idle* moment where a health application could be used. In the following section, we describe the design of one such application, which was named *The (Poo) Review*.

[2] http://bits.blogs.nytimes.com/2012/01/30/the-rise-of-the-toilet-texter/



(a) Initial Ratings (b) Bristol Stool Chart

Figure 1: Adding ratings to *The Poo Review*. The user (a) first gives 3 ratings for *Quantity*, *Solidity*, and *Satisfaction*, and then (b) selects a category from the Bristol Stool Chart. Finally (not shown) they can add some text to their review.

3. APPLICATION DESIGN

An application for the scenario above would have a number of goals. It should (a) allow users to anonymously *input* data and create a personal profile, (b) convey *educational* information and (c) empower users to *share* reviews if they so desire. Of course, we also aimed to make the application fun and simple to use. We further explicitly decided to not connect the first prototype of this application to the smartphone's camera or to social media (e.g., Facebook).

We built an Android prototype to meet these goals. The application uses two components: the Android SDK for the native application and the Google App Engine[4] for data storage and dynamic information delivery, and is currently available via Google Play[5]. Users of the application are identified by means of an anonymous id: when they first

[3] http://www.nhs.uk/bowelcancer

[4] https://appengine.google.com/

[5] https://play.google.com/store/apps/details?id=com.poo.review

install the application, the server allocates a unique, persistent 6-digit pin code to them. The home screen of the application then greets the user with three buttons ("Review," "My Profile," and "Friends") and a random picture of a toilet (collected from Flickr images tagged with a Creative Commons license), which will change each time they return to there. We decompose the functionality of the application into the following three categories:

3.1 Review Input, Information Output

The main task of the application is for users to review their current bowel movement. They do so via a 4-fold review process:

1. **Numerical Ratings**. The first screen (Figure 1(a)) asks users to input three ratings. They are asked to give a 1-5 star score for the *Quantity* (1* is "Not much," 5* is "Lots!"), *Solidity* (1* is "Diarrhoea," 5* is "Constipation"), and the *Satisfaction* (1* is "Not at all!" 5* is "Much better!") of passing their current stool.

2. **Categorical Choice**. The second step (Figure 1(b)) asks users to select a category that best describes their current stool. We opted to use the 7 categories described in the Bristol Stool Chart, which was defined in [19] as a means to monitor stools' intestinal transit time and assess the effectiveness of treatments for bowel diseases. We used the category descriptions defined on the chart's Wikipedia page[6]; the only minor change we made was to add names to each category, as can be seen in Figure 1(b).

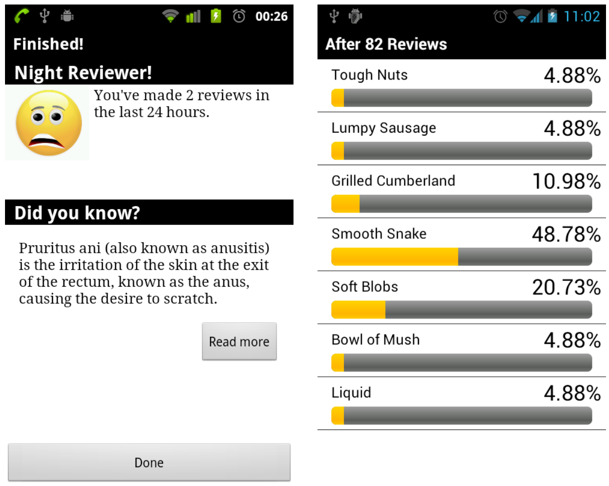
3. **Current Location**. The user has a choice to add a location to their review. The locations are statically defined (e.g. Home, Work, Friend's House, Restaurant), and the user can also select to hide their location.

4. **Textual Feedback**. Finally, users have the option of adding a short comment to their review.

Once the four steps have been completed, the user submits their review (via the "Flush Review" button). The review is then stored to the phone's local database, and sent to the remote server. The server replies with a randomly selected entry from a fact repository, and feedback is given to the user (Figure 2(a)). This result page contains two main components:

1. **Personalised Feedback**. The top half of Figure 2(a) is tailored to the user. The heading changes based on the current time of day, and the smiley is dynamically set based on the last rating: for example, if the user has input a "Liquid" review, the face is unhappy, while if their numerical rating showed high satisfaction, the smiley is happy (there are a total of 9 different smiley categories). Lastly, a textual fact relating to the user's reviews is shown. A range of candidate facts are possible, relating to both time (e.g., the user's 7-day frequency average, the number of reviews in the last 24 hours, the time of the last review), and category (e.g., the last time they input a review with the same category): a fact is chosen randomly from the available candidates.

[6] `http://en.wikipedia.org/wiki/Bristol_Stool_Scale`



(a) Review Feedback (b) Category Profile

Figure 2: (a) Example feedback that the user receives after "flushing" a review, including personalised and generic facts, and (b) an example from the user's profile page, showing the distribution of categories generated by all reviews.

2. **Generic Fact**. The bottom half of Figure 2(a) is a generic fact under a "Did you know?" heading. These facts have been collected manually from Wikipedia, and include snippets about defecation, the digestive system, minor bowel problems, and healthy eating. The server also returns the Wikipedia link to the source of each fact, which is used to set the target of a "Read More" button that accompanies the snippet.

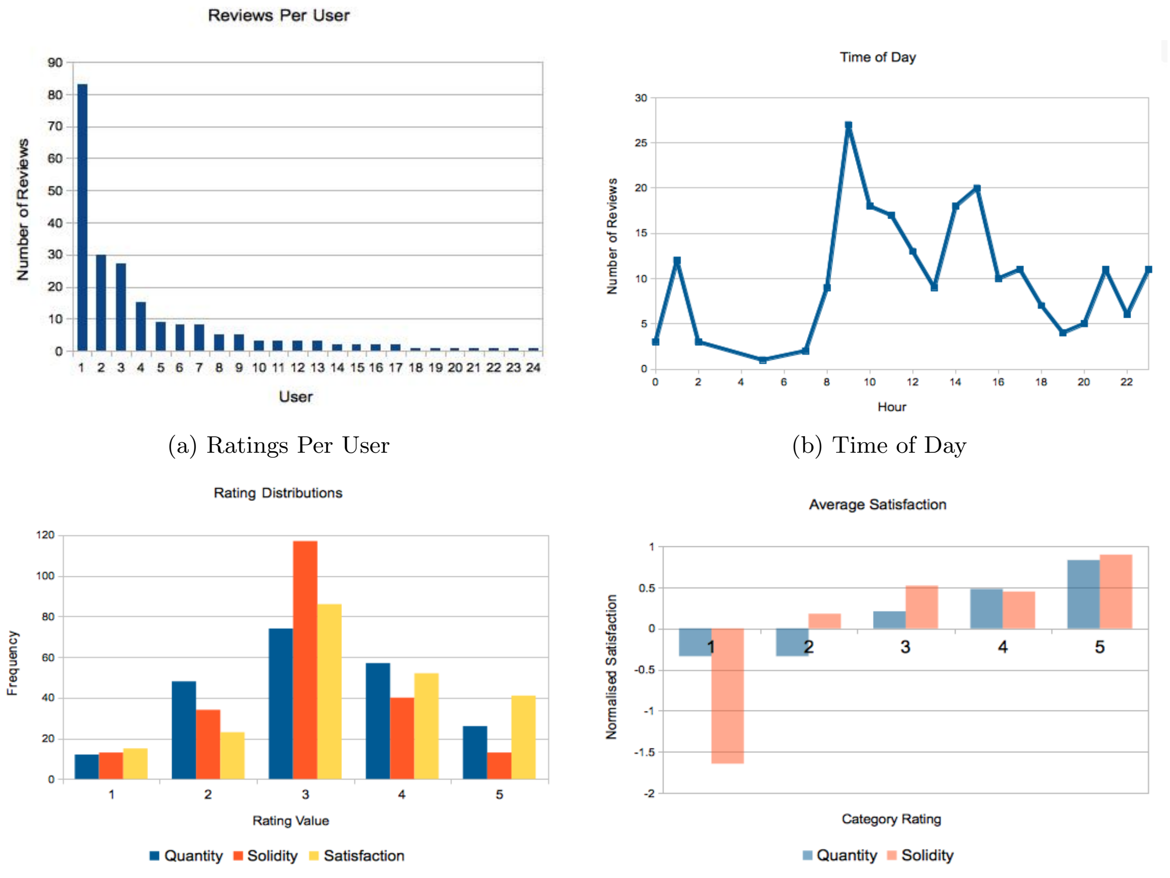
3.2 User Profiles

The set of reviews that users input are used to create the "My Profile" views in the application. The profile is split into two halves. The first section reports the user's 7-day statistics (number of reviews, average reviews per day) and allows the user to see a list of recent reviews. The second section contains the aggregate data. This includes both the total number of reviews as well as distributions of aspects of the reviews: for example, Figure 2(b) shows the aggregate distribution of categories selected by the user, visualised with both percentages and progress bars. Similar distributions are available for the locations and times of day when reviews tend to be input.

3.3 Sharing Reviews

Preliminary discussions with a variety of people regarding the potential to share reviews resulted in diverging results. Few people found the idea to be obscene, embarrassing or disgusting (which accurately reflects the social stigma that awareness campaigns are tackling); others indicated that they already regularly share their toilet-going experiences with a select number of others (e.g., friends, partners, parents). While further work is certainly required to understand the extent that sharing of such experiences already happens, these preliminary results led us to build a basic sharing functionality into the application.

Since users are identified by the system with a pin number, they must input a name of their choosing in order to



(a) Ratings Per User (b) Time of Day

(c) Ratings Distribution (d) Normalised Satisfaction

Figure 3: (a) Distribution of reviews per user; the current system actually only has a handful of active users; (b) time distribution of submitted ratings, showing morning and early afternoon peaks; (c) the distribution of quantity, solidity, and satisfaction ratings across the 5-point scale, and (d) the normalised relationship between ratings and average satisfaction (a negative value denotes average low satisfaction for the rating category).

enable sharing. The "Friends" button on the home screen then leads to a news feed of reviews by a user's friends. This news feed contains any reviews that have been *explicitly* chosen to be shared by the friend who input them. Each entry contains the friend's name, a time stamp, and the review category—clicking on the entry will pop-up the friend's numerical ratings. Two further constraints apply: first, only those reviews input by friends within the last 7-days are displayed; furthermore, there is no means to visualise a friend's aggregate data (as included in Section 3.2 above). Adding friends to the application is currently a manual procedure: users must input their friend's pin number to send a friend request, that must then be accepted by the friend. The application does not support searching from friend pin numbers by, for example, e-mail. This is to allow users to continue to use the application anonymously, and also forces them to exchange pin numbers via other means: in order to share, the users must find a means to exchange pins outside of the context of the application first.

4. EARLY USAGE AND DATA

Since its release to the Google Play market (March 19, 2012, less than 1 month ago), the application has accrued 35 users (as counted by the number of unique pin numbers the system created; users who uninstalled and later re-installed the application would have two entries). In this section, we report on early data reflecting the application's usage and the reviews that have been input: it serves to show the analysis that will be possible if the application user base is sufficiently scaled.

4.1 Reviews Received

The server has, to date, received 217 reviews from 24 different users (that leaves 11 users who have downloaded the application but never submitted a review). The distribution of reviews per user is shown in Figure 3(a). This is the kind of long-tailed distribution that many web systems exhibit; however, it reveals that, among those who have downloaded the application, there are few active users.

Among these active users, trends are beginning to appear in the times that reviews are submitted. Figure 3(b) shows when the reviews have been submitted, after binning them into the hour of the day. The two highest peaks correspond to the morning (between 8 and 10AM) and early afternoon

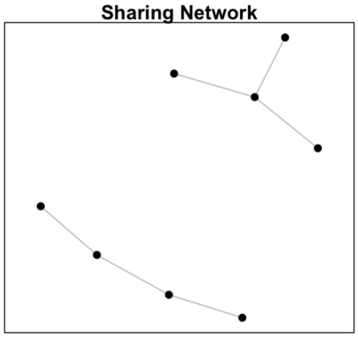


Figure 4: The structure of the initial review-sharing social network.

(2 to 4 PM); in the future, these results could be compared to any in the medical literature to see how they correspond to previous diary studies during bowel treatment trials.

The ratings are roughly normally distributed around the 3* value across all three numerical scales: Figure 3(c) plots the rating value frequency distributions. We also delved further into the relationship between the *satisfaction* and the other two ratings (*solidity* and *quantity*). For the latter two, we first computed the binned average satisfaction per rating class (for example, the average satisfaction when users rate their solidity 3*). We then normalised the data by subtracting the overall average rating from each bin (which was *solidity* = 3.17*, *quantity* = 3.02*) and plotted the results in Figure 3(d). The results demonstrate, unsurprisingly, that the lowest satisfaction is input when users report having diarrhoea (*solidity* = 1*), or very low quantity stools. Satisfaction remains positive even when users report that they are constipated (*solidity* = 5*); perhaps this is explained by the satisfaction of being able to input a review at all.

4.2 Is Anyone Sharing?

Approximately one quarter of the users (9) have enabled sharing on the application: of these, 6 use a name to identify themselves (such as "Alice" or "Bob") while the other 3 use identifiers that are not human names. However, 1 user who has enabled sharing has not added any friends. All other friend requests have been approved; the system currently has no pending or rejected friend requests. A total of six friendship ties have been established. We mapped the social links in Figure 4. This small set of users are partitioned into two groups: a chain of 4 users who only link to one friend, and a cluster of 4 users who are all connected via one node.

Users also have to manually opt in to share each individual review: approximately 1 in 3 reviews are shared (32.25%). Those reviews that are shared are also likely to have a textual comment appended to them: 87.8% of shared reviews have text (on aggregate, only 18.8% of all reviews have text). The preliminary data also does not show differences in the text between reviews that are shared and not shared: this may indicate that users who add in text are later forgetting to opt in to sharing their review.

The overview of the data above highlights the early usage of the system and demonstrates the potential of what could be uncovered if the system were adopted by a large user base. In the following sections, we discuss some of the implications related to both this specific application and, more broadly, any that is designed for health monitoring during idle moments.

5. DISCUSSION

There are two open problems relating to building technology that enables health self-monitoring via smartphones. First, there is the danger that over-monitoring may lead to self-diagnosis and stress (Section 5.1); furthermore, technological solutions for health contexts may negatively impact people's tendencies to seek and give social support to those around them (Section 5.2).

5.1 Data Without Diagnosis

The current version of the application allows users to review their bowel movements without linking their data to any means for automated diagnosis or comparing them to any notion of "normal" behaviour. Furthermore, personalised facts about their reviews are presented as-is, without any qualitative information appended. This was a specific design decision: not only do we assume that the definition of *normal* may be culturally-dependent, but Internet-based interventions for those with bowel problems actively encourage people to *not* over-monitor their bowel movements [16], as this may lead to stress (from questioning whether they are "normal") which may exacerbate any pre-existing problem.

This issue, however, remains open. Conversely, it would be rather straightforward to encode a means to detect and alarm the user if reviews reflect, for example, those symptoms that Cancer Research UK is seeking to raise awareness about [18]. Furthermore, comparisons and interfaces that emulate competitive scenarios (e.g., Foursquare's leader board) have been shown to be drivers of early user engagement with mobile applications [20]; enabling comparisons of one form or another may be a solution to the low user engagement observed in Section 4.

5.2 Reconnecting with Each Other

One of the aims of the application (as well as ongoing awareness campaigns) is to help users overcome the social stigma of openly talking about their experiences. The technical approach to aide this is achieved by allowing users to share their reviews with one another and capturing those *idle* moments when people tend to turn to their mobile phones. Smartphones are such a promising technology for the health domain both because they are constantly with us and because they are increasingly gaining greater amounts of our attention: recent research by Ofcom[7] reveals that 37% of adults and 60% of teenagers feel "highly addicted" to their smartphones.

The problem here is that designing health solutions around an "addictive" technology, by leveraging and incentivising people's affinity to turn to their mobile phones, may also entail encouraging people to remove themselves from their social circles. Turkle [21] further explores this problem: systems that draw people in and given them control of what they broadcast may contribute to the problem rather than help solve it: they change, detract from, and act against nurturing those face-to-face relationships where talking about health may be the most important.

[7] `http://media.ofcom.org.uk/2011/08/04/a-nation-addicted-to-smartphones/`

6. CONCLUSION AND FUTURE WORK

This paper has introduced the design and early data of *The (Poo) Review* Android application: a tool to review bowel movements that captures the fact that users regularly use their smartphones in the lavatory, where they are likely to be alone and willing to engage with an application that allows them to trace their health. In doing so, we have explored the potential for health-related applications designed around *idle times* and discussed a variety of design issues that surround this context. There are a number of possible means to take this application forward; we close here by discussing a number of different ideas.

The application is currently designed to be a lightweight and fun tool. However, the medical research literature (e.g., [19]) uses diary studies as a means to assess the success of bowel treatments. The app could thus be used to replace and automate the collection of diary data during periods of clinical trials, allowing for larger scale studies to take place. Similarly, awareness campaigns are currently targeting the media to educate people about symptoms to look out for: an application like this could be a complementary means to engage with the public throughout the course of such campaigns.

The application could also benefit from adding support for the questionnaires that web-based systems targeted towards those with minor [17] or diagnosed [16] bowel conditions; a mixture of positive feedback, emphasis on reassurance and goal-setting (instead of the reviews) may allow the application to be a mobile version of these web interventions.

Finally, the application currently asks the user about a single activity. Future iterations could extend this in order to visualise correlations between activities. For example, the application could have two modes: one that allows users to take photos of their food, the other asking for reviews as above. This would allow users to compare what they eat with their reviews; however, it also introduces the potential to misuse the application. Similarly, users could be asked to review other aspects of their lifestyle (e.g., diet, sleep, stress, or indeed a user-defined variable) or sensors could be activated to detect aspects of their lifestyle [14].

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