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ABSTRACT

We present the design and evaluation of a smartphone app, *QuittyLink,* designed to help smokers reduce or stop smoking. Smoking cigarettes is a serious health risk and people who wish to quit often struggle to do so. It is well known that the most effective method of assisting smoking cessation is personal face-to-face counseling. However, this approach is only used by very few people wishing to quit for reasons such as inconvenience and personal shyness. In response to this we have created an app that provides personal counseling to users on their smartphone. The counseling content is authored by smoking cessation experts and is based on the user's personal data and recent actual smoking behaviors collected through the smartphone. We deployed the *QuittyLink* app with people in their everyday lives to study how personal counseling on mobile phones would influence their smoking behaviors. We found that both the personal counseling and the ability to visualize and reflect on their own self-tracked smoking behaviors helped them form strategies to improve their ability to quit.

Author Keywords

Smoking cessation; health behavior change; mobile apps; personal counseling; self-tracking; interaction design.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

With the growing proliferation of mobile technologies, we are witnessing several mobile applications that support and encourage behavior change within different domains, such as physical activity, healthy eating and drinking, stress management, alcohol abuse, smoking cessation, etc. In this paper, we are particularly interested in the use of mobile technologies for supporting people in changing smoking behaviors and, more ideally, quitting entirely.

Figure 1. Participant using *QuittyLink* while smoking

Smoking can impact personal health with varying degrees of severity, with illnesses including cancer, lung disease, heart disease, and poor blood circulation [15]. Despite this, and widespread campaigning against smoking, consumption of tobacco continues to grow, and according to the World Health Organization almost six million people die every year from smoking-related diseases [22]. Illness and deaths from smoking are not only tragic, but also have significant economical costs for societies. As a means of facilitating smoking cessation, it is well known that personal face-to-face counseling is very effective. However, it is also well known that this approach is not very popular amongst potential quitters for reasons such as inconvenience of having to be in a specific place at a specific time for the counseling, and shyness of going to a counselor in person.

In response to this, we have been exploring the use of personal mobile technologies, such as smartphones, for facilitating and mediating personal counseling in smoking cessation. Personal smartphones are particularly interesting as platform for this purpose because of their pervasiveness and hence the ability to use them for reaching people at times and places where they are tempted to smoke. They are also interesting because they facilitate real-time collection of information about the smokers' context and smoking habits. Our prototype application, *QuittyLink*, combines these two into a mobile personal counselor, using health behavior change strategies, tailoring its content to the individual smokers' profile, smoking behavior and context, and delivering it into the users' own contexts rather than requiring them to go to a counseling appointment.

In the following we outline related work and describe the *QuittyLink* app. We then describe our field deployment of the prototype with people trying to quit smoking, and present and discuss our findings.

RELATED WORK

In recent years there has been an increase in interest in the use of technology to support health behavior change - both in terms of commercial products and research projects. Popular for every day use are the commercially available wrist worn fitness bands including Apple Watch[1], Fitbit[2] and Jawbone[3]. Each comes with different options, but common to all is collecting and presenting data about the user's physical activity. Fitbit Flex tracks steps, distance, calories burned and how much a person has slept. Apple Watch Sport tracks heart rate, physical movement and calories burned. Jawbone Up tracks daily activity, calories burned, sleeping hours, meals and even has a barcode scanner to record food items consumed. HCI research has successfully explored the use of tracking technologies for automated and more accurate data input. Consolvo et al. [4] developed a prototype mobile app called *Houston* for encouraging physical activity by using a pedometer to count the steps a person takes each day and presenting this to the user on their phone to be shared with others. Chui et al. [3] created a system called Playful Bottle to motivate office workers to drink healthy quantities of water. This system uses a mobile phone attached to a drinking mug. The camera and accelerometer of the phone are used to track the amount and regularity of water consumed. *Fish'n'Steps*, created by Lin et al. [10] encourages physical activity by growing virtual fishes in a fish tank the more steps a user takes. Similarly, *UbiFit Garden* [5] uses a virtual flower garden as a metaphor which grows as the user is more physically active, using a fitness sensing device to track activity and the garden is then visualized on a personal mobile display. In all of these systems, the activity tracking with subsequent visualizations helped people understand their health behavior changes and gave them indicators of when they had reached activity goals.

There are limited research examples of technology supporting smoking cessation. Early studies by Strecher et al. [20] using computer-tailored health letters to support participants' smoking cessation found them to have statistically significant positive results toward quitting, in an attempt to overcome the low numbers (less than 0.5%) of people who access and are helped by face-to-face counseling when quitting [2]. Strecher [19] later confirmed that computer-tailored content delivered through the web was more effective than non-tailored content. Shiffman et al. [17] and Schuman [16] both confirmed the efficacy of computer-generated tailored quit smoking materials. Graham et al. [9] developed a web-based system called QuitCoach to provide quitting advice to users, tailored to their quitting stage, using the Trans Theoretical Model of

health behavior change [14]. Among the studies exploring the use of mobile technology to support smoking cessation, "Txt2stop" by Free et al. [8] found that sending helpful text messages to participants doubled their quit rate in the short term. Similarly, "Distract Me" by Ploderer et al. [13] showed that distractions and tips on mobile phones could keep users from smoking. Extending on these findings, Paay et al. [11] explored how different types of content sent to mobile phones could help smokers quit. They found that content that relates directly to peoples' smoking habits were most helpful. Participants also requested interaction in the form of contact with a quitline and the tracking of their own habits in order to better engage with the app. They also liked the smart phone as a delivery platform. In related work, Paay et al. [12] found that smokers are highly individual in their approach to quitting and that the help required at different stages of a person's quitting attempt needs to be tailored to their particular situation and seen as specific and relevant to them.

Abroms et al. [1] reviewed 98 apps for Android and iPhone, finding that nearly half of them simply provided calculations based on estimates by the user, and that the apps generally had low adherence to evidence-based practices. The problem with basing feedback on estimates provided by the user, long after the act, is that data is often incomplete, imprecise and prone to error. Immediate and automated tracking of cigarettes smoked can solve this.

THE "QUITTYLINK" APP

Based on findings from previous studies on health behavior change and smoking cessation, and the review of existing apps, we designed and built the *QuittyLink*, which uses self-tracking and system-tracked data about a person's smoking behaviors to provide weekly personal counseling to their mobile device similar to the normal weekly rhythm of many in-person smoking cessation counseling programs. We also provided visualizations of their measured smoking behaviors, as well as daily motivations and tips, which have proven helpful in previous studies [11, 13]. The aim was to both help people to quit smoking and support them in staying quit.

QuittyLink was developed as a native application for both iOS and Android, rather than as a web application, in order to better exploit the technological advantages of the smartphone platform. Developing native applications ensured that graphics looked as intended, location-based information could be easily recorded, and the app ran faster than a web-app delivered through a browser. We kept the app simple and fast to use, since it was designed for data entry or browsing content while the user was smoking. Making native apps for the two most popular platforms meant that they could each be designed with respect to the design principles of that operating system, taking advantage of user's interactive familiarity with their own phone.

Contextual attributes such as time, place and social situation can become conditioned cues to smoke. Situations

are crucial in a person's urge to smoke [21]. Certain situations trigger strong cravings in individuals, for example, after meals, when drinking alcohol or coffee, when taking a break. Keeping track of these triggers and other contextual attributes can increase smoker's awareness of their behavioral patterns and assist them in making and maintaining strategies to change. To facilitate this kind of assistance, our system asks users to register each time they smoke or resist a cigarette coupled with the triggering situation. The *QuittyLink* system then logs the time and physical location of the phone when these entries are made. By tracking smoked and resisted cigarettes precisely, and presenting this data as a set of visualizations on the user's phone, they can become more aware of their actual smoking patterns. This makes *QuittyLink* useful to smokers who are thinking of quitting or trying to quit, as well as smokers who are working to stay quit. In doing this, we counteract one of the biggest limitations of current apps, that is, most are only useful for smokers who have already quit [1].

Counseling has proven to be highly effective in increasing people's success in quitting smoking [19]. Even so, many people are reluctant to seek it in person, or attend smoking cessation groups because they see quitting as a private matter, or find it inconvenient to attend counseling at a set time and location [19]. As counseling is such an effective smoking cessation technique, we wanted to take advantage of the privacy and flexibility provided by mobile technologies to deliver regular personal counseling to the smoker. To support these factors further, *QuittyLink* logs data about the user's smoking habits, which is then sent to a quitline expert. The expert then delivers weekly counseling tailored to each individual. This can then be read at a place and time of the user's choosing, even reviewed later, potentially reaching smokers who would otherwise not seek personal counseling.

QuittyLink Interaction Design
The interaction design of *QuittyLink* was kept as simple as possible to encourage people to use it frequently during their day. The system was designed in Denmark to be used with the general population. To make it accessible to a wide variety of people with different backgrounds, educations and ages, the system was created using the Danish language. For the purpose of this paper, we have provided English versions of the screens, pertinent to understanding the design concept. *QuittyLink* has three tabs corresponding to the main interactive parts of the app: *Track*, *My Data* and *Tips* (Figure 2). Since smoking cessation counseling in Denmark is free as part of the free health care system, we also made the *QuittyLink* app available for free.

The *Track* screen (Figure 2a) has very few elements and very simple interaction. It is used to register the number of cigarettes "SMOKED" or "RESISTED" each time. If they have smoked, they need to press the red button the exact number of times corresponding to the number of cigarettes smoked in that session. Whether they have smoked or resisted users can then choose from a predefined list of 10 different situations that triggered them to want to smoke (e.g., relaxation, work, party, coffee/tea, driving, morning routine). They can tick as many as are relevant or an "other*"* option if their particular trigger is not listed. To complete the input the user presses "Save" at the top of the screen, and the time, date and location of the smoking episode are recorded automatically by the system coupled with the input information. All data is saved to a server.

The *My Data* facilitates selection between three different visualizations of the user's smoking history in an easy to read and understand format. Common to all is the intention of provoking self-awareness by providing accurate information about a persons smoking habits over time. They are able to see whether they are reducing the number of cigarettes over time, how often they resist having a cigarette, and the kinds of locations and situations that trigger their smoking.

The *Process* line graph (Figure 2b) shows the number of cigarettes smoked over time against the number resisted, allowing people to compare the two and draw their own conclusions about what that might mean. Above the graph
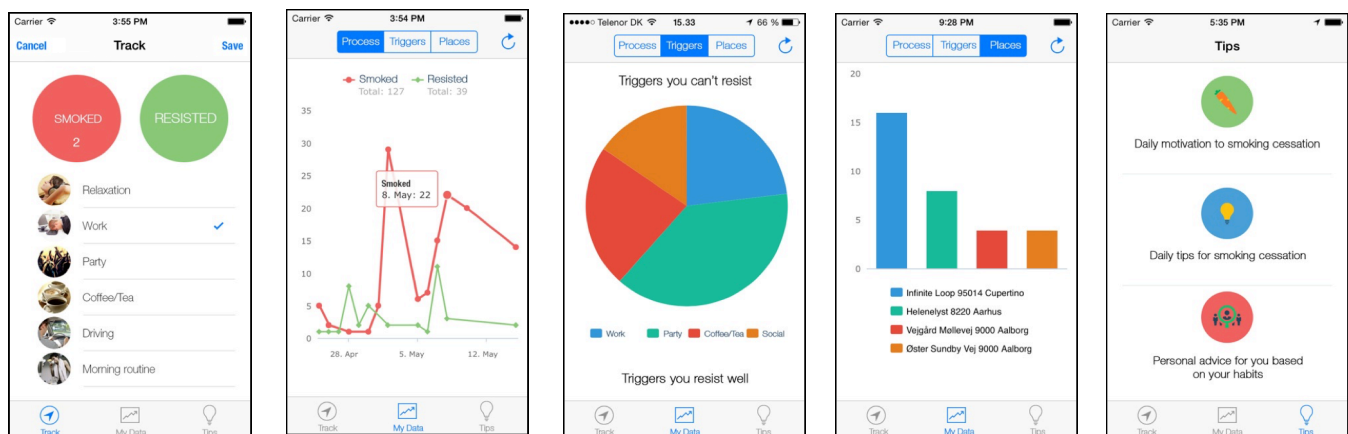

Figure 2. *QuittyLink* screens: a) Track, b) My Data-Process, c) My Data-Triggers, d) My Data-Places, e) Tips

the total numbers of smoked and resisted cigarettes since they started using the app are shown. A user can get information about the exact number of cigarettes smoked on a particular day by tapping on the point on the graph.

The *Triggers* pie chart (Figure 2c), "Triggers you can't resist" shows the proportions of different situations that have triggered smoking episodes, (e.g., work, party, coffee/tea, social). This gives smokers insight into what situations trigger them to smoke most often. Tapping the bottom label "Triggers you resist well" activates an alternate chart showing the same information about resisted cigarettes. The user can toggle between these two charts. They can also tap on the pie slice to find out the exact number of cigarettes it represents.

The *Places* bar chart (Figure 2d) shows how many cigarettes have been smoked at different locations, given as street addresses (e.g., Helenelyst 8220 Aarhus). This gives users an understanding of where they tend to smoke the most, helping them to reflect on the kinds of locations (and hence perhaps situations) they need to avoid, or be more aware of in resisting their cigarette cravings. Common to all of the My Data visualizations is the intention of provoking self-awareness of smoking habits from self-tracked data. This can lead to people adjusting their behaviors in response to this knowledge and has proven useful in other fields of health behavior change [7].

The Tips screen (Figure 2e) gives access to three different content types: *Daily motivations to smoking cessation* (factual statements about the pros and cons of smoking), *Daily tips for smoking cessation* (easily implementable piece of advice) and *Personal advice for you based on your habits* (tailored personal counseling). Motivational stories and daily tips are sourced from various online quit help sources, and updated daily by the system. A daily motivation might be, for example. *"Cigarette smoke contains over 4000 chemicals and 69 of these are known to cause cancer."* An example of a daily tip is *"Some smokers say that the taste of citrus reduces cigarette cravings, so start your day with a glass of orange juice."* A daily SMS reminder was sent to inform users of new content and to prompt them to use *QuittyLink*.

Figure 3. Personal Counseling based on smoking habits

Personal counseling from STOPLINEN smoking cessation service, Denmark, was provided weekly and tailored to the

participant's own situation, with the opportunity to contact the counselor directly for follow up advice. It was delivered directly to the participants smart phone, based on tracked data on the smoker's habits from the past week, including number of cigarettes coupled with trigger situations, times, and locations (see Figure 3). Push notifications alerted users to the arrival of their personal counseling messages.

FIELD STUDY

We conducted a field study of *QuittyLink* in everyday use over a period of three weeks. This study duration allowed people to get used to the app as part of their every day life (as opposed to a snapshot study of use) and allowed us to give a each participant counseling feedback a number of times. The aim of the study was not to investigate sustained behavioral change, which would have required a much longer study duration, but explore how smokers responded to entering data about their smoking habits and then receive personal counseling advice based on this input, direct to the *QuittyLink* app. We also wanted to see if the *My Data* visualizations prompted self-reflection on their smoking habits and the effect that this and/or the counseling had on their ability to reduce cigarette intake, in the short term. The field study was conducted in Denmark in spring of 2014. The app was delivered using public app stores, and so it was possible for people not directly recruited to the study to sign up for the app and join. Participants were asked to use the app every day as part of their normal smoking routines for the duration of the study.

Participants completed a demographic survey that included information about their smoking habits. Of the 13 participants in the study 4 were male and 9 female. Participant age ranged from 22 to 52 years with a mean of 35 and a standard deviation of 11.8. Seven of the participants had an iPhone and six had an Android device. Eleven participants had previously tried to quit smoking. Six were thinking about quitting, 4 were preparing to quit and 3 were trying to stay quit. Based on Fagerströms test of nicotine dependency [6], 3 participants had no dependency, 2 had very low dependence, 6 participants had low to moderate dependence and 2 had high nicotine dependence. See Table 1 for details.

During the study, each participant was asked to use the app every day whenever he/she smoked a cigarette or had a craving. All participants received a new motivation and tip each day, with an SMS to remind them to use the app. Once a week, the tracked data for each participant was collected and sent to the counselor. Based on their initial survey responses and the tracked data from the past week, participants then received personal counseling messages, typically 15-25 lines, from the expert counselor. All content sent to the participants remained accessible at all times, so they had the possibility to revisit advice as needed.

Participant	Age	Gender	Nicotine dependency	App entries
1.	47	F	Low to moderate	146
2.	43	F	High	26
3.	24	F	High	8
4.	22	F	Low to moderate	8
5.	22	F	Very low	31
6.	45	F	Very low	7
7.	26	F	None	76
8.	51	F	Low to moderate	6
9.	52	F	Low to moderate	198
10.	25	M	None	14
11.	45	M	Low to moderate	112
12.	30	M	Low to moderate	80
13.	26	M	None	30

Table 1. Participant overview

After the study, we conducted semi-structured interviews with each participant to discuss their experiences with *QuittyLink* and the role it played in their smoking cessation. Questions covered general impressions of the app, entering data, reading graphs, impact of their personal counseling messages and suggestions for improvements. During the interview, we used information about their use pattern and their logged interactions with the app to ask individual and specific questions. We were interested in their reflections on their smoking habits and whether they felt they had changed during the study. We asked how motivated they were to quit smoking as a result of their experience with *QuittyLink*, and compared this to their response to the same question in the online survey at the beginning of the study. All interviews were audio recorded.

Data analysis was done using qualitative content analysis with partial transcription on audio recordings, as this was an explorative design study. Researchers listened to the tapes individually, noted the issues discussed at each section, compared notes, and then fully transcribed selected parts.

FINDINGS
Our participants used the app quite differently ranging from 6 entries for one person to 198 entries for our most active participant (where each entry may contain more than one smoked cigarette). The mean number of entries was 57 and the standard deviation was 61.8. Although we discouraged it, we found that some would enter the day's cigarettes all in one entry before going to bed at night. It seemed that for some this would be more convenient and recalling time and place for a smoke seemed less problematic for these people. In the following, we report our findings as three overall themes on personal counseling using our mobile app.

Learning about Time and Place for Smoking
In terms of the feedback provided by the graphical visualizations, 7 out of 13 users said that they learned something new about their smoking habit. One said, "*I*

found out that I smoke the most at home and when passing time...I always thought that if I smoked, it was because I was stressed. So my justification to smoke is not really honest." All 13 found it highly motivating to get a simple and informative picture of their smoking patterns, however, all also mentioned a desire for the ability to choose the time frame of the graphs, in particular, to be able to compare this week's activity with last week. All participants reported being more motivated to stop smoking. We found that they expressed a general liking and interest in tracking smoking habits. All 13 found the app easy to use and 10 out of 13 not too time consuming, "*Yes, very, it was easy to use, even to me who is bad at using technology*", and, "*Easy and fast. It takes a quarter of a second to open and then you just press save and 'bang', you are done*". Most participants, 11 out of 13, found the daily SMS reminders useful, and did not mind receiving them, although smokers who were not feeling motivated to quit tended to not like being reminded to use the app each day. The SMSs successfully reminded participants to use the app every time they had a craving.

Convenient and Pertinent Mobile Counseling
Users preferred the convenience of receiving counseling on their mobile phone rather than having to contact someone. Thus, it seemed that mobile counseling holds great potential. We further found that regardless of the age, participants were keen on using their smartphone for smoking cessation. Quite interestingly, participants who had not yet committed to quitting said that registering resisted cigarettes made them crave a cigarette even more. Thus, the app sometimes had counter-productive effects. Ironically, one participant rewarded himself with a cigarette for resisting one, "*Good job, you have done well, smoke a cigarette for that.*" But participants who were serious about quitting or trying to stay quit found the Resisted button and graph very useful and liked that they could see their own progress over time. In relation to registering resisted cigarettes it should be noted that when resisting an urge to smoke, the urge often doesn't go away. Hence people could, theoretically, keep clicking the "RESIST" button and thereby registering one resisted cigarette as many resisted ones. However, we did not hear of any such use of the app to inflate the number of resisted cigarettes.

We observed a direct correlation between users' motivation to quit and their acceptance of counseling messages. Eight of the participants, who took their quitting attempt seriously and wanted to change their habits found them personal, motivating and helpful, saying, "*It gave me more motivation. That I am going to make it...the counseling helped me find out by myself that I was ready to stop*". Those not ready to quit, the other 5, who did not see their smoking as a problem, said the counseling made them feel pressured. All participants appreciated that the counseling messages were personalized, "*It means a lot that it was written specifically to me, what I should do, and not what others should do*".

Effects of Mobile Smoking Counseling

Nine of the participants reported a positive change in their smoking habits after the three weeks of use. They had either reduced their consumption or *QuittyLink* had supported them in staying quit, "*The app had a major impact; it has helped me to think about my consumption. It helped to postpone cigarettes.*" Many mentioned that knowing that a real person (the counselor) had put time and effort into writing the personal messages was a great encouragement and motivation to quit. The 4 who did not change behavior during the study reported that *QuittyLink* at least made them reflect more on their habits, potentially inspiring future behavior change, "*I have found out where my weakness lies. I think more about it every time I light a cigarette*".

DISCUSSION AND CONCLUSION

This study contributes findings in terms of the ease of self-tracking smoking behaviors, the perceived usefulness of visualizations of smoking habits, SMS reminders, and the convenience and efficacy of personalized counseling delivered directly to a person's smart phone. We confirm the positive effects of these features on changing people's health behaviors, with respect to our particular *QuittyLink* design, as detailed above, and the field study showing that these designed features were particularly effective with smokers who had already committed to trying to quit.

Through a field deployment, tracked data, and follow-up interviews, we gathered and documented insights about the potentials and challenges of designing an effective smoking cessation app, thus contributing to the body of knowledge on technology-assisted smoking cessation. Most important in our results was the finding that providing personalized counseling on smart phones, based on data about the individual user's actual smoking habits, collected via the phone, was very positively received by users. This offers promising potential for quit organizations to provide one of the most effective quit mechanisms (personal counseling) to a much wider audience than clinics are currently able to reach. As covered by [2, 19] the problem has not been lack of counselor's time, but unwillingness by smokers to seek institutional help, for reasons such as inconvenience or reluctance to put themselves "out there", etc.

While computer-tailored content for smokers is not a new idea, using actual counselors to write personal advice specifically for that individual, based on their actual smoking patterns and delivering it to them on smartphones is new - and it proved to be a motivator to both participate in recording their activities, and reducing their cigarette intake. Involving users in tracking of data about their smoking habits helped make them aware of when, where and why they smoked thus supporting them in taking action to change that behavior if they wanted to. To our knowledge, this combination of real-time self-tracked and system-tracked data providing a very detailed picture of peoples' smoking habits is a new approach to smoking cessation technology design. Especially when this data is then used to both provide visualizations for personal reflection and expert counseling advice.

We discovered that *QuittyLink* promoted self-awareness and self-motivation and provided effective guidance and support for people wanting to quit smoking. We further found that the tracking offered by *QuittyLink* was considerably more accurate than smoker's own perceptions of their smoking habits, and that this allows people to develop more effective personal quitting strategies. Finally, we found it interesting that self-tracking of "resisted" cigarettes can be counterproductive, leading smokers in an early quitting stage to actually smoke as a reward for resisting. We will use this and other findings from our study to redesign future iterations of *QuittyLink* that take account of smokers' individual differences.

Although we achieved positive results in our study, much more work is needed to explore long-term strategies for effectively using interactive mobile technologies to facilitate smoking cessation, but we can see that this research represents a very promising start.

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