

Trajectories of Engagement and Disengagement with a Story-Based Smoking Cessation App

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ABSTRACT

Strong user engagement with digital technologies for behaviour change is often taken as a precursor to their longer-term efficacy. We critically examine this assumption through a qualitative study of a smoking cessation app, called NewLeaf, which allows quitters to swap personal stories. The study examined what influenced people to engage or disengage with NewLeaf, and how the app was deployed in quit attempts during a four week trial. Several properties of swapped stories were reported to promote engagement, including: authenticity, currency, contextualization of advice, and evoking a sense of community. But while the resulting engagement was sometimes productive in supporting quitting, other trajectories of use were observed involving counterproductive engagement, and a surprising pattern of productive disengagement especially among stronger quitters. We discuss how this analysis of different trajectories problematizes any simple interpretation of user engagement as an early indicator of success for behaviour change technologies.

Author Keywords

smoking cessation; health behavior change; engagement; qualitative research

ACM Classification Keywords

H.5.3 Group and Organization Interfaces: Web-based interaction.

INTRODUCTION

Persuasive technology has been a prominent area of HCI research with more than 100 papers at CHI over the last 10 years focused on behaviour change in health and other domains [15]. While the key idea of designing for behaviour change has been popular, the original notion of

persuasive technology [11] has been critiqued on a number of fronts [5]. One is its prescriptive stance on what behaviours are deemed desirable, often with a lack of consideration for personal needs and desires [2], and for individual circumstances [9]. There has been debate about whether 'one size fits all', or whether more sensitive design is needed for varying motivations of individuals at different stages of change [14].

In the area of health behaviour change, research into new technologies also faces significant methodological challenges [17,30]. It is typically beyond the scope of HCI research to measure final health outcomes for a population, or even for a sample of study participants. Reasons include, as Klasnja et al. [17] have cogently argued, that the timeframe of health interventions can be several months or years, and that generalizable outcomes are best established through randomized control trials (RCT) as favoured by medical research. Although possible in principle, a longitudinal RCT can lead to a different research focus that takes emphasis away from HCI design. Instead, Klasnja et al. argue in favour of HCI researchers using intermediate indicators of success.

To contribute to the understanding of this burgeoning class of digital technology, our aim here is not to measure the effectiveness of a particular technology or technique, but rather to provide a qualitative account of *How and why people engage with digital tools in their attempt to undertake behaviour change*. Rather than seeking a normative account, we are concerned with the variety and even idiosyncrasies of users and uses. Implicit in much health app design, and related HCI research (including that of the authors), is what can be called the *engagement-efficacy perspective*: the belief that greater engagement with a health technology is a precursor to its longer-term efficacy in addressing the targeted health condition. Taking this perspective does not assume that engagement is sufficient to achieve efficacy, nor even that it is a causal antecedent, but simply that greater engagement is a positive early indicator, in the sense described by Klasnja et al [17], and therefore a good outcome for HCI design.

Some researchers report counter-findings to the engagement-efficacy perspective, identifying cases where people disengage from a technology as part of the positive

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continuation of their behaviour change, including the 'gateway effect' [29], 'happy abandonment' [7] for various reasons [10]. We aim to build on these accounts and to further critically examine the nature and significance of engagement with behaviour change applications.

The study we report here focuses on smoking cessation. We designed a mobile app, called NewLeaf, and evaluated it with 23 people who were attempting to quit smoking. Despite many developments in recent decades to restrict and curtail the smoking of cigarettes in several countries, almost 6 million people are estimated to die each year from smoking-related disease worldwide, with forecasts of 8 million deaths per year by 2030 [35]. Smoking cessation has therefore been one of the targets of HCI researchers interested in persuasive technology [21, 23, 24, 26].

Underlying our study is a shift away from the persuasive technology paradigm which puts emphasis on whether a tool can 'persuade' people to change. Instead, our premise is that digital tools are better seen as *resources*. Whether users of NewLeaf would successfully embark on a quit attempt is the result of many external factors relating to personal motivation and circumstances. Our concern is not whether NewLeaf acts as the driver of success, but rather with how people might engage with its suite of resources, and how they might deploy them positively, or otherwise, in their quit attempts. And within this, we ask whether engagement with the app is associated with positive experiences of attempting to quit.

NewLeaf was designed with three potential quitting resources. Chief among these was an online forum for people to exchange their personal stories of attempting to quit, widely believed to be a powerful and engaging health resource [18]. For comparison, NewLeaf also provided expert health tips, and online distractions to combat cravings. The app thereby provided multiple options for engagement, thus serving the aims of our study.

BACKGROUND & RELATED LITERATURE

Engagement and behaviour change technology

Engagement is a vital but notoriously hard to define concept in HCI. For Sutcliffe, it is what makes a technology 'attractive' and 'fun' to use [32], while for O'Brien and Toms it is the much broader 'quality of user experience characterized by attributes of challenge, positive affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, interactivity, and perceived user control.' [20]. Turner has emphasised the centrality of the 'affective' dimension of engagement 'consistent with both our contingent identities and our wider purposes' [33]

Although our study was designed to examine the affective experiences of users of NewLeaf, we use the term 'engagement' here to mean the degree to which people use a digital aid in a way that relates to the purpose of behaviour change. Thus engagement refers to the extent and manner in which people actively used the resources of NewLeaf to

help them quit smoking. Conversely, the term 'disengagement' is used to mean withdrawing from active use of the tool.

In the case of smoking cessation, much research shows that smokers are highly reluctant to engage with online social support tools because of concerns about self-presentation, and embarrassment of failure [19]. It is not surprising, then, that designers and researchers set user engagement as a desirable goal. Hence, the engagement-efficacy perspective is implicit in much research and development.

As an illustration, studies in this area are often premised on the reasonable assumption of making apps, or other technologies, more engaging to increase the likelihood of behaviour change down the track. For example, Paay et al [21], through a design workshop with smokers, report that they desire advice that is personalized for their needs, that they can relate to and which is tailored to their stage of quitting (e.g., intending to quit, or currently making a quit attempt). Similarly, Agapie et al [1] designed a system to help people create behaviour change plans with strangers and friends. Interviews showed that participants responded to plans more positively when they were tailored to their goals, routines and preferences. Reno and Poole [26] examined whether and how people would respond to a request for social support to quit smoking on Facebook, and found that people are 10 times more likely to offer support to friends and family members compared to strangers.

Disengagement and behaviour change technology

However, there is also a growing number of counterpoints to the engagement-efficacy perspective. Rooksby et al. [27] used an interview study to uncover a variety of motivations for engaging with personal health apps and devices. Alongside productive uses, were non-productive forms of engagement, e.g., a desire to document one's lifestyle, collect rewards, or simply a fetish for gadgets and technology. A recurring finding of studies of wearable health and activity monitors is that they are typically abandoned after a few months because motivation drops, needs are not met, or because people change to a different system [7,12]. Schwanda et al. [29] have termed this latter outcome the 'gateway effect', showing that persuasive technology can work as a conduit to new activities, and thus reduced engagement with a tool is not always a sign of failure.

In the context of personal energy use, He et al. [14] argue that the design of new technologies aiming to support behaviour change should consider differences among users. In particular, they draw on the transtheoretical model [25], to argue that technologies should engage adaptively to people at different stages of behaviour change, from pre-contemplation, contemplation, preparation, action and finally maintenance of the change. He et al. conclude that 'if technologies are adaptive, a dynamic component should be present (e.g., social networks), as technologies cannot be expected to keep up with complex human motivations'.

The value of personal narratives in behaviour change

An important element of our study was the use of personal stories as a powerful form of content to engage users in behaviour change [13]. By focusing specifically on how personal stories might engage quitters, we are drawing on a long history of research into the benefits of health advice in narrative form [22]. For example, Mamykina et al. [18] designed a story-based mobile health application for people with diabetes, and demonstrated its value for users to maintain a positive self-image, to reassert their competence and to maintain continuity in their self-image over time.

More generally, many researchers report that role models and norms conveyed through narratives can influence behaviour change [16]. Borland [3] argues that habitual behaviours like smoking can be effectively influenced through stories, because they influence our actions on an unconscious level. However, there is also a line of evidence that shared stories may work to protect people's connection to social situations in which the adverse behaviour is prevalent, as in DeSantis' [8] account of cigar smokers.

STUDY METHOD

The NewLeaf smoking cessation app

To explore our questions, we designed and built a smartphone app, called NewLeaf (see Figure 1), which allows smokers to share personal quit stories. Unlike many of the studies reviewed above, which used interviews, design workshops, and hypothetical responses, our aim was to study the role of NewLeaf in real-life quit attempts that took place over the first four weeks following a decision to quit.

Ploderer et al. [24] studied a quit app that presented expert tips about quitting and distractions to cope with cravings for cigarettes. We included these two kinds of content in NewLeaf to serve as comparisons with the personal stories. Most prior work on the power of narratives for health behaviour change has focused on the use of professionally-authored content [16]. In contrast, we were interested in the kinds of engagement achieved by community-generated stories written and shared by smokers and quitters.

To ensure that we had a thriving community from the outset, we drew content from the forum 'StopSmoking' hosted on the Reddit website. This forum receives about 30 posts a day from smokers and ex-smokers and is moderated by long-term quitters. Reddit has a publicly available API that makes it possible to pass content to and from the Reddit server. StopSmoking is pseudonymous and authors are not required to identify themselves. It is known that the anonymity of Reddit contributes to increased self-disclosure in online discussions about sensitive issues such as mental health problems [6].

Our NewLeaf app presented quitter stories from the StopSmoking forum and allowed users to read and post content. We removed many of the features of the full Reddit site, and reduced the rapid turnover of posts so that

some stories remained visible for longer. For consistency, both expert tips and distractions were presented in the same way as stories, with comment trails following each item. The expert tips were sourced from counsellors at Quit Victoria, a smoking cessation agency at which one of the authors is based. To source distractions, we allowed users to choose a Reddit forum of non-smoking content relevant to their interests; examples chosen included jokes, world news, science, contemporary art.

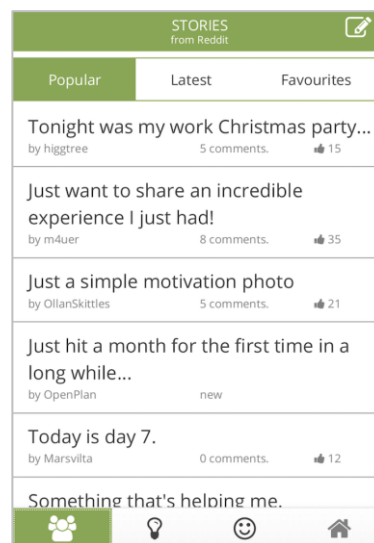


Figure 1. Screen-shot from the NewLeaf app showing a listing of stories, and buttons along the bottom to reach expert tips, distractions and home

Participants and the study procedure

Thirty participants were recruited into the study via an advertisement. Seven did not return for a second interview, leaving 23 participants aged between 23-50, split 11/12 between males and females. They were recruited on the basis of two criteria: being adult smokers who were considering a quit attempt, and being smartphone users.

A first interview was held with each participant to find out their smoking history and quit intentions, and to introduce the app and configure the distractions page to a forum of their choice. Participants were then left to use the app as they wished over the following four weeks. A second in-depth interview was held towards the end of the fourth week to probe experiences of quitting and the nature of engagement with the stories, tips and distractions. Participants were compensated \$25 per interview for their time and travel costs. We took strong steps to reduce the potential bias of participants believing they needed to be positive about the app. They were encouraged to be critical, and emphasis was placed on comparing their experience of stories, tips and distractions.

A thematic analysis drawing on the techniques of Braun and Clarke [4] was carried out, using transcribed audio-recordings of the in-depth second interviews, to identify the nature and forms of engagement and disengagement with

NewLeaf. We also tracked usage patterns by recording every 'click' in NewLeaf made during the 4 week trial.

FINDINGS

A common criterion for successful quitting is to be smoke-free for 6 months [34]. It was not possible therefore to examine participants' success of smoking cessation, but rather we focussed on how their quit attempt was proceeding and their engagement with the app.

Based on the second interviews at week 4 of the trial, participants were classified according to the reported success of their quit attempt so far. We first distinguished between those who presented as 'Succeeding' so far (S) from those who presented as 'Not-Succeeding' (N). Among those Succeeding, we further distinguished between those who had totally abstained from smoking throughout the trial (S1-S8) from those with a qualified report (S9-S16) in which they had either cut-down and were on track to quit, or were quitting but had experienced minor relapses. Among those who were Not-Succeeding, we distinguished those who had not managed to make any quit attempt (N1-N4) from those who had tried but relapsed (N5-N7).

Light smokers, who smoke 5 or less cigarettes per day [28], are likely to find quitting less challenging than heavier smokers. Given our intention to explore the variety of experiences we included them in our study, but to provide greater context we label them with the letter L, e.g., S6L.

Participants were asked directly in interviews if they had an overall positive, negative or neutral experience of using each of the three resources in NewLeaf: stories, tips and distractions. These affective responses are summarized in the top rows of Figure 2 (heavy smokers) and Figure 3 (light smokers). Positive experience (shown as +) implies that participants spoke of valuing the resource and believing it to be useful for quitting. Negative reactions (shown as x) implies that participants reported that the resource was annoying, off-putting, pointless, or similar. Figures 2 and 3 show that there was a variety of reactions to the three forms of content. Figure 2 indicates that, among the heavier smokers, stories were more likely to have produced positive affect (shown as + in Figure 2) by participants who reported that they were Succeeding in their quit attempt than by those who were Not-Succeeding. This pattern was not evident among the light smokers (Figure 3).

The lower panels of Figures 2 and 3 show the intensity of usage of NewLeaf over the first 3 weeks of the trial, measured by the number of significant interactions with the app. We do not include the fourth week where there was often a spike of usage during and around the second interview. A significant interaction was defined as one of the following: the opening of a specific content item (story, tip or distraction); posting of an item of content; favouriting or unfavouriting of an item; upvoting or downvoting an item; a login. A score of 1 in Figures 2 and 3 thus represents a simple login to the app, and might involve the

undetected browsing of content lists, but did not involve opening of specific items or responding to them. Scores above 1 indicate the inclusion of some of these more significant interactions, up to the highest daily score of 405 which implies a prolonged session of many significant interactions.

Most striking in Figures 2 and 3 is that there is no apparent association between the intensity of using NewLeaf and either the status of participants as being Succeeding or Not-Succeeding, or the affective responses of participants to stories, tips and distractions. Succeeding participants S2 and S12, for example, show high intensity usage over the 3 weeks, but Not-Succeeding N4L, N5, N6 also show moderately high usage. Conversely, the lowest usage is shown by 3 Succeeding participants, S7L, S3 and S11, with the Not-Succeeding N3 and N7L also being relatively low intensity users. This qualitative dissociation between intensity of use and the status of quit attempts is a significant observation which informs our discussion of engagement patterns below.

Trajectories of engagement and disengagement

Thematic analysis of the second interviews revealed a rich variety of experiences in using NewLeaf, including both positive and negative reactions to the app and its value in supporting a quit attempt. Figure 4 shows a conceptual model that was developed through our analysis to classify patterns of engagement and disengagement. We will overview this model first, before describing the evidence that underpins it.

The model in Figure 4 depicts attempts to undergo digitally-mediated behaviour change as a journey, or trajectory, from a current to a desired behaviour state; in this case, from being a smoker to being a non-smoker. In between are various intermediate states defined by different forms of engagement or disengagement with the digital tool. Alternative trajectories of attempted behaviour change are shown in the form of paths that people might follow through these various states. Each person's trajectory may contain a mixture of 'steps forward' towards the desired state, or 'steps backward' towards the current state. The trajectories in Figure 4 are not meant to be exhaustive, but rather they reflect prominent observed patterns in our study participants.

The model thus shows how attempts at digitally-mediated behaviour change might progress along very different trajectories. From the current state as a smoker, each person undertakes *exploratory engagement* with the app, a step which was induced by the procedure of the first interview of our study. Once into the trial, a participant may then shift to a state that we describe as *productive engagement* meaning that they are actively consulting and applying the resources of the app to quitting. However, as our model shows we observed other states that allow for alternative trajectories: *counterproductive engagement*, *non-productive disengagement*, and *productive disengagement*. In the

		Succeeding									Not-Succeeding				
Participant		S2	S12	S5	S1	S9	S4	S10	S3	S11	N5	N6	N1	N2	N3
Base rate cig/day		20	10	8	30	20	10	20	12	10	20	6	10	10	7
		Affective response to NewLeaf resources: + positive x negative (blank indicating neither)													
Stories		+	+	+	+	+	+	+	+		x	+	x	x	x
Tips		x	+	x					x	+		+	x	+	x
Distractions		x	+		x			x				x	x		
		Intensity of Use: Counts of significant interactions with NewLeaf													
Week 1	1	405	70	34	108	12	15	44	25	26	30	20	11	13	22
	2	224	18	47	26	24	59	1			36	15		12	2
	3	175	16	15		57	25				14	10	6		
	4	111	3			26	9						3		
	5	134	14			1					28				
	6	109	3	16							6		19		
	7	75	6	34							5	18		4	
Week 2	8	46										9			2
	9	73	4								15				
	10	67	2								16				
	11	55	21								5	12		6	
	12	24	3			6								1	
	13	97	4						4			16			2
	14	58										1			
Week 3	15	32	13												
	16	27									4				
	17	30	11												
	18	55	2										3		
	19	48	11										1		
	20	21	1							3			1		1
	21	34	4									13			

Figure 2. Data for heavy smokers: Base rates of smoking (top panel); Participants' affective response to stories, tips and distractions in the NewLeaf app (middle panel); and tracking data of the total number of significant interactions with the NewLeaf app by each participant during the study (lower panel) (See Findings section for the definition of significant interactions.)

following sections we explain and describe these states, the evidence for them, and the resulting trajectories.

Productive engagement

Productive engagement is a state envisaged, and hoped for, under the engagement-efficacy perspective. While we argue here is that there are other significant states and trajectories that arise, productive engagement is nevertheless a very important state. This section now considers the shape that productive engagement took in our study by identifying the characteristics of stories, and sometimes expert health tips, that were reported as eliciting meaningful and positive engagement with NewLeaf.

Authenticity, currency and contextualized advice

Participants who were positive about posted stories spoke of them as being more *authentic* than the expert health tips. Curiously, although the stories were themselves simply textual posts, they were experienced as somehow more 'real'

and alive than expert health advice: *'it's perspective from real people, real time rather than you're reading a blog post on the internet'* (S2); *'I mean the tips are just tips, like expert tips but the things people post they are real and this actually happened to them'* (S12). Just four Succeeding quitters and two Not-Succeeding quitters, reported that expert tips were valuable because of the credibility of the source (S11, S12, N2, N6). But there was less need to engage with tips frequently as a Not-Succeeding participant pointed out: *'the first few days I saw all the tips that were there ... so it's not like I'm going to be using that feature every day'* (N2).

Related to the sense of the authenticity around stories, participants were positive about their *currency*; that is, they recognised that the stories were recently created, a result of the high turnover of posts and growing comment trails. In contrast, the expert tips were more static: *'if I jumped back in it's like 'oh, I've seen that one already. Why is that still*

	Succeeding							Not-Succeeding		
Participant	S15L	S13L	S6L	S16L	S8L	S14L	S7L	N4L	N7L	
Base rate cig/day	3	5	3	0.5	1	3	2	2	4	
	Affective response to NewLeaf resources: + positive x negative (blank indicating neither)									
Stories	+		+	x	+	x		x	+	
Tips		x				+	+			
Distractions	+	+		+	x	+		+	x	
	Intensity of Use: Counts of significant interactions with NewLeaf									
Week 1	1	51	54	36	19	30	5	16	21	13
	2	1	27		8	2	8		12	
	3			31					20	21
	4	1			12	1			14	2
	5	8							4	
	6				9	1				
	7	48	6		3		19		13	
Week 2	8	6		13					16	
	9	14								6
	10		37							
	11		18						2	
	12								2	
	13								31	
	14	14				4			34	
Week 3	15	1	6			2			4	
	16		2			9			14	
	17	10				3				
	18		2							
	19									
	20	4			15				3	
	21									

Figure 3. Data for light smokers: Base rates of smoking (top panel); Participants' affective response to stories, tips and distractions in the NewLeaf app (middle panel); and tracking data of the total number of significant interactions with the NewLeaf app by each participant during the study (lower panel) (See Findings section for the definition of significant interactions.)

sitting there?' It was mainly to hear what other people were saying' (N6).

The greater attraction to stories over expert tips was not because participants were avoiding practical support. On the contrary, and consistent with the notion of productive engagement, most participants strongly preferred stories that contained specific advice that was *contextualized* within the personal narrative: 'I'd prefer that someone who is say on the same page as I am gives me that information rather than a doctor ... ' (S5). As suggested by one participant, the attraction of authenticity, currency and contextualized advice was that they created a sense of agency in the quitter; a feeling that the decision to quit comes from the quitter themselves, and not through obedience

to a health expert: 'there's still a lot of people out there that are trying to quit, not because we're forced to quit but because it's our own decision to do it' (S9).

Identifying with the story poster

A further critical aspect underpinning productive engagement was whether participants could identify with the poster's situation and experience: 'Oh, some of them are textbook cases of me, it's like I could have written it' (S3). For most participants, identifying with others at the same stage of quitting was powerful: 'it's like relating your experience to theirs and trying to find what you can do about it.' (S12). Some participants noted specifically how similar experiences elicited a particular kind of empathetic engagement: 'for me it was helpful because I started going

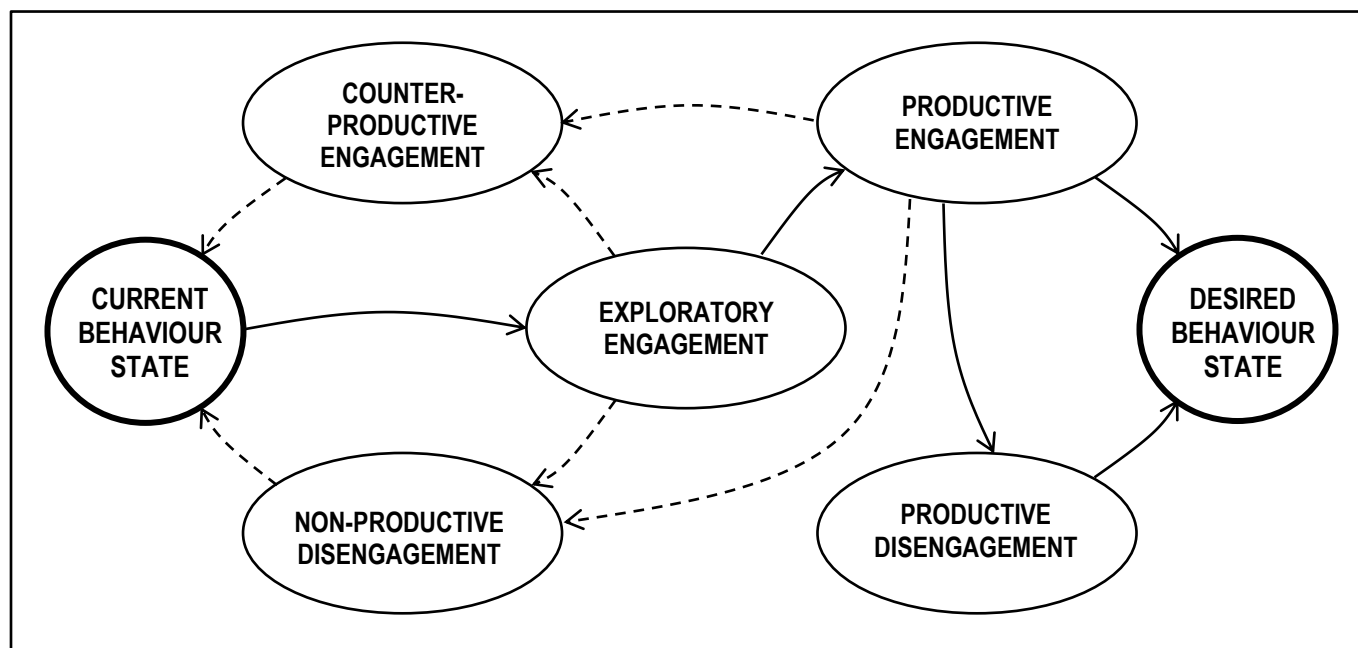


Figure 4. A conceptual model of alternative trajectories of digitally-mediated behaviour change. Solid arrows indicate progress towards the desired behaviour state (of being a non-smoker), while dotted arrows show regression back to the current behaviour state (of being a smoker)

through a lot of, like, the panic stuff and the anxiety stuff and all of that came up for me that's never been there. So it was good to read.' (S2).

Limits of productive engagement

Nearly all participants valued the fact that the online community of quitters presented by NewLeaf was separate from their everyday world of family, friends and colleagues. They valued their anonymity, with many commenting that they would not want to conduct this activity in Facebook. But although they felt secure in the anonymity of NewLeaf, there was extreme reluctance to post content, even among the Succeeding quitters who were productively engaged: *'I know its anonymous but I'm hiding from myself.'* (S3); *'I guess because there is always that chance that you might not succeed and you don't want to put it out there in the public domain.'* (S13L). Others posted with trepidation: *'At first I was like one of those shy people "Should I say something? Should I not say something? What are they going to think of what I've said?" ... and so I ummed and ahed for a while before I hit the button'* (S9). One clear exception to this was the intensely productive engager S2 who did post and interact successfully: *'... it was quite good and it was when I started ... and it was really rough and they kept checking in, "How are you doing now?"'* (S2).

Non-productive disengagement and counterproductive engagement

As captured in our model in Figure 4, however, not all participants achieved anything resembling productive engagement. For some, lack of interest in the stories, tips and distractions meant that the app simply failed to provide any support for a quit attempt, a state we describe as *non-*

productive disengagement. For example, the Not-Succeeding N2 reported how initial exploratory engagement led to non-productive disengagement: *'it really was really informative and it reminds you of how difficult it is, at the end of the day, to quit ... I'm not the sort of person who engages that much with initiatives like that'* (N2)

More interestingly, we also observed *counterproductive engagement* with NewLeaf which involved more sustained use of its quit resources, but with the opposite of the intended effect. This was often expressed as antipathy towards success stories posted by ex-smokers, that grew into a stance against the spirit of NewLeaf and against quitting generally. N6, for example, was a relatively frequent user of the app and a keen reader of stories. But while liking some stories, she experienced ex-smoker stories negatively: *'they're doing it to help and give you encouragement, but I didn't see it that way. I saw it as "I can't believe you have time that you can be bothered doing this" and it didn't make me feel "oh, one day I'll feel like that"'*. (N6) Unusually, N6 went from smoking 6 cigarettes per day to 20 by the second interview, reporting this as being related to other circumstances; again confirming the importance of external factors in participant outcomes.

Also illustrating counterproductive engagement, the light smoker N4L was a relatively steady engager with stories. But for him the experience was overall very negative: *'reading some of the guys' successful experience is... you know, it's like torture to me, because I'm a failure, I didn't make it happen'* (N4L). Further, N4L was adamantly opposed to the potential for social interaction through NewLeaf: *'... I really don't want you guys to make this ...*

like a social app, like Facebook or Twitter ... I don't want two-way. Yeah, one-way is enough...' (N4L). Such negative experiences were high among the Not-Succeeding participants. N1 found it too difficult to engage with any story: *'I just couldn't really relate to myself ... It's like I don't know, ... I don't even know who they are'*. And the idea of posting was repugnant: *'I don't want to expose myself in that sense to others, or strangers, and saying like oh I can't do this or whatever'* (N1). For N5, who had successfully quit in previous years but since relapsed, this sentiment was even stronger: *'... to read people's stories who'd been really successful and gotten a year of not smoking and had really progressed ... I remember what that was like but it was a little bittersweet to read them because I don't know that I had a great deal of faith in myself to be able to get to that point again.'* (N5). N5 did post a story, but the limited response led to more discouragement: *'The responses I got from the big long post were fine but it was all kind of short'* (N5).

Productive disengagement

We now come to the identification of a fourth significant state in the trajectories of some participants, that of *productive disengagement*. This describes situations where participants, who were productively engaging with the app and embarked on a succeeding quit attempt, then actively decided to disengage with the app because it was reminding them of smoking. This was the most striking and surprising observation of our study in which reduced engagement with NewLeaf was associated with a strong quit attempt. Productive disengagement is related to phenomena like the gateway effect [29] in which a tool outlives its usefulness or where people progress from one behaviour change resource to another. But it is significantly different. Productive disengagement was not simply NewLeaf reaching the end of its relevance, but involved the active decision to suppress all reminders of the behaviour state of smoking, including quit resources.

Productive disengagement was evidenced primarily in interview reports, but it is also supported by the usage logs, particularly for heavier smokers (Figure 2). It can be seen that while S2 and S12 maintained productive engagement across the 3 weeks of the trial, the other 7 Succeeding quitters stopped almost abruptly during the first week. As one put it: *'I think an app like this has to be something you can use and stop using ... there are some people who clearly come back to this forum years after they've quit but I think most people would rather get that over with'* (S9). The problem of giving up smoking was transferred to, or at least combined with the problem of giving up the app. For some, productive disengagement was not just with the app, S1 reported the same for nicotine chewing gum: *'I just didn't want to have to be to a schedule like smoking cos I'd just be thinking about smoking every time I was doing something.'* (S1).

The state of productive disengagement was noted as being different from the earlier attraction to the app during productive engagement when the aim was *'just keeping the idea of quitting alive in your brain ... like it'd just keep reminding you'* (S10). For participant S9, the realisation that she would need to productively disengage with NewLeaf appeared to occur relatively early on at the outset of the quit attempt. It co-existed with the initial desire to productively engage, and this set up a conflicting initial experience: *'... it was just conscious sitting on my mind that I want a cigarette but I should use the app. Then using the app is actually reminding me of a cigarette'* (S9). This conflict underlay caution about posting her own stories, because it could seem to lock in a form of engagement: *'I have to remember to go back and read what I wrote and did I have replies and that's more of "You're thinking of cigarettes" sort of a thing.'* (S9). Many participants spoke of a desire to go back to the app in the distant but not immediate future: *'you don't want to be reminded. However, I would still... like to check stories of people who have quit for as long as I have or even longer, so I can ... I can look beyond, you know, and aim for like a bigger goal.'* (S5)

The active maintenance of productive engagement and productive disengagement

What characterized the Succeeding quitters in our study from those Not-Succeeding was the way they were able to actively follow a trajectory of productive engagement, often followed closely by productive disengagement. They appeared to use adaptive strategies to stick to this trajectory and to avoid counterproductive engagement or non-productive disengagement. This was despite the Succeeding quitters suffering many of the same negative reactions to stories in NewLeaf as the Not-Succeeding participants.

For example, even among the Succeeding quitters, there was discomfort with the perceived triumphalism of ex-smokers, particularly if they did not express the struggle to reach success: *the stories ... helps you in understanding or helping you through your quit process ... well yeah everything except the ones that say "a hundred days"* (S12). The health tips in NewLeaf could also provoke negative reactions: *'We all know how lung cancer looks like ... It's not like we're back in the 40s and the doctor would open the consulting room with a cigarette in his mouth and tell you smoking is good for you. We know that it's not good for you.'* (S5)

But Succeeding quitters typically avoided moving into a sustained form of counterproductive engagement, by selecting stories that fitted their stage of quitting and which they could relate to and use productively: *'... there's a lot that "I've had a cigarette and I've relapsed" I don't read those ... I do not need verification that you could go backwards.'* (S2); *'So on the first days I would click on stories going my first week as non-smoker, and these days I would go more for like one month'* (S5). Only two of the Succeeding quitters (S3, S10) broke with this pattern and

were keen on reading the fully variety of stories: *'it's human and it's good to see the fails as well as the successes because the fails reminds you that even though a person can fail they know what they want to do, they know what's right'* (S3).

It was through the Succeeding quitters' disposition to engage productively with NewLeaf that some experienced through the app a world of people who did not smoke: *'And you see that there are certain people that are very, very prominent already that people mention and go back to and they comment on nearly everything, they're quite active. So it's nice to know that they're there, I guess.'* (S2). This sense of another world appeared to grow from the engaging characteristics of stories, especially their authenticity and currency. Succeeding quitters spoke of this world as one they might soon join. S9 put it: *'Not a quitting club but part of a nice, big group'*. As these quitters productively disengaged with the app, there were signs that they were not rejecting that online world, but rather attempting to transplant it on to their real lives. S5 spoke of going to music festivals, a major trigger for smoking, and how she would in future, as a non-smoker, have an altered engagement with people, and how the stories on the app helped her to see that more positively: *'So when you feel like you're going to lose that, so it's good to feel that you're gaining, you're part of another community that you just didn't know about it or you didn't think about it basically.'* (S5) Conversely, for the Not-Succeeding quitters, who did not enjoy the story forum, it was a counterproductive rejection of any future scenario of being a non-smoker that often underlay their reaction. Participant N5, who made a serious attempt to engage and quit before relapsing, reported: *'maybe it felt a little bit distant for me like... I don't think I was willing to engage in some sort of solidarity with other people in it.'* (N5).

DISCUSSION

From our study of 23 people's real-life attempts to quit smoking, we have presented a picture of the rich variety of their responses to using an app for behaviour change. The model in Figure 4 offers a way to interpret this variety by conceptualizing alternative trajectories that people might take, passing through different states of engagement and disengagement with the digital aid. The trajectories shown in Figure 4 depict the key paths observed in our study.

Importantly, our model expresses a dissociation between the intensity of using a digital tool and progress towards a desired behaviour state. Four states of the model express this dissociation. Productive engagement entails positive progress in behaviour change coupled with high app use, while non-productive disengagement entails negative progress with low use. Together these are the expected outcomes under the engagement-efficacy perspective that we argued is implicit in much design and research. However, two other states captured in our model are inconsistent with it. Counterproductive engagement entails

negative progress in behaviour change coupled with high app use, and productive disengagement entails positive progress with low use.

Our account is supported by the lack of a qualitative association between the intensity of people's interactions with the NewLeaf app and the reported success of their ongoing quit attempts during the first 3 weeks. For the heavier smokers (Figure 2), 2 of the Succeeding participants (S2 and S12) used the app intensively for the whole trial and continued for several days after. But the other 7 Succeeding participants used the app intensively only on the first few days of the trial but then used it very little if at all. Our interpretation, as expressed in the model of Figure 4, is that while S2 and S12 engaged productively with NewLeaf throughout the trial, many of the other Succeeding quitters moved along a trajectory from exploratory to productive engagement, then after a few days on to productive disengagement.

Among the Not-Succeeding participants there was also great variation in the intensity of interaction with the app, but more intermittent use of it across the trial. Some of the Not-Succeeding participants exhibited quite high levels of use but this was often in a state of counterproductive engagement, particularly N5, N6 and N4L. These participants were consumed by an antagonistic reception of other peoples' quitting stories, especially, but not only, those of triumphant ex-smokers. This was distinct from the other Not-Succeeding participants who were not antagonistic but merely failed to engage, a reaction which we describe as non-productive disengagement in Figure 4.

Productive disengagement is a surprising and striking observation of our study. It is related to, but nevertheless distinct from, other reported forms of reduced engagement during behaviour change, such as the 'gateway effect' [29] and 'happy abandonment' [7]. These effects imply situations where people have succeeded with their change, or switch to upgraded or different technologies. Productive disengagement as observed here, in contrast, involved the active attempt to banish thoughts about smoking, and this required not thinking about quitting too. The timing of transitions from productive engagement to disengagement were variable but could happen after as little as one or two days; time for a quitter to gain enough motivation, through the app or elsewhere, and then proceed to a state of not thinking about smoking or quitting.

This interpretation, of a form of active and productive disengagement, as opposed to losing interest, is confirmed by the fact that 8 of the 9 Succeeding quitters in the heavier smoking group (Figure 2) were very positive about the value of stories. They valued them as authentic and current, and preferred them as a source of advice over the expert health tips. Conversely, 4 out of 5 Not-Succeeding heavier smokers had a negative reaction to stories which led some on a trajectory from exploratory to counterproductive engagement, and others from exploration to simply

disengaging non-productively as they gave up the tool and their quit attempt. All returned to the current state of being a smoker and not attempting to change, at least for now. While we do not claim any causal connection between the use of stories and quitting, interview testaments, at least for the heavier smokers, were consistent with the idea that engaging productively with stories in NewLeaf was a likely characteristic of people embarked on a Succeeding quit attempt, and not engaging productively with stories more often characterized those who were Not-Succeeding.

These finding can be considered in terms of the trans-theoretical or stages model of quitting. Consistent with He et al's [14] argument that behaviour change apps should tailor their content to people's stage of change, most participants in our study preferred to engage with stories from people in a similar situation to themselves. Moreover, their preferences changed as they moved from being 'just quit' to maintaining an ongoing quit attempt. It was also evident that the Succeeding quitters were able to adaptively select stories to match their situation, suggesting that a story forum can provide 'one size to fit all' in some circumstances. To do this, it must support ready identification of the poster's stage of quitting. It was notable that many Not-Succeeding participants were not able to find suitable stories, and many were fixated on stories that they found off-putting.

Implications of the trajectories model

As noted earlier, Klasnja et al [17] argue that HCI researchers working on health technologies cannot easily measure their success by final health outcomes, so instead they should use intermediate indicators, such as the uptake of behaviours believed to have a positive influence. Engagement with the technology may appear at first to be one such intermediate indicator, in terms of the strength of affective response or in terms of intensity of use. While engagement is of course important, our study points to the dangers of relying on strong user engagement with a behaviour change app as an indicator of success.

The model of alternative trajectories, developed here (Figure 4), offers a set of potentially valuable sensitizing concepts for designers of behaviour change technologies, especially for addiction support. The notion of productive disengagement, in particular, suggests that users need the utmost control over when and how they use these devices, and points to the dangers of conventional prompts like notifications that seek to remind or otherwise draw users back into direct engagement. Rather, the user should be free to disengage and stay disengaged and this should not be treated as a failure of either user or technology. Equally, users should be free to lurk and observe without even gentle coercion to post content or comments. Again such interactions can be perceived as locking in a form of engagement that was not attractive to participants in our study, including those who were Succeeding so far in their quit attempts.

These implications of productive disengagement are mostly applicable to technologies that help people combat addictions like smoking, gambling, alcohol and drug use. In these situations, it is desirable to reach a state of not thinking about the objects of addiction. Other kinds of behaviour change, such as energy conservation, are less relevant perhaps and involve valid goals to make the need for change an ongoing awareness. Yet even in these situations, the notion of productive disengagement has relevance, in that users should preferably internalize new ways of thinking and new habits, so that they become independent of tools. Recent research supports this approach for assistive technology; for example, Stawarz et al [31], working on medication reminder tools, argue for designs that achieve technology-independent habit formation as opposed to ongoing technology-dependence.

CONCLUSION

Our study offers new evidence about the variety of forms of engagement and disengagement with digital tools for behaviour change. It reveals how strong user engagement can sometimes be a positive sign, but only if the user is productively engaged with the tool. However, engagement may be counterproductive, as with antagonistic reactions to content that push users away from their original goal. Equally, users may undertake a counter-intuitive form of productive disengagement in which they actively decide to discontinue using a digital tool. This is not a rejection of the value of the tool, but rather a strategy to banish thinking about adverse behaviours in a positive continuation of the attempt to change.

Our resulting model of alternative trajectories of engagement and disengagement (Figure 4) therefore suggests caution against any simplistic interpretation of usage tracking data as an indicator of success for HCI design of tools for behaviour change. People's trajectories in this domain are typically too complex and subtle to be captured in a numerical log of usage frequency or intensity. At least in the context of addiction support, our model suggests that behaviour change apps should be designed to give users maximum control over their level of engagement and disengagement and avoid features such as notifications that seek to trigger or even lock in particular patterns of use.

Finally, our study illustrates a different perspective to that of persuasive technology. Whether people embark on behaviour change is a result of many external factors, of personal motivation and circumstances. Rather than our NewLeaf tool being seen to persuade people, it is better understood as a resource that allowed Succeeding quitters to channel their various sources of motivation to embark on an attempted behaviour change.

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