Self-Monitoring, Self-Awareness, and Self-Determination in Cardiac Rehabilitation

Julie Maitland
People-Centered Technologies Group
National Research Council Canada
46 Dineen Drive, Fredericton, NB, E3B 2R4
julie.maitland@nrc-cnrc.gc.ca

Matthew Chalmers
Social/Ubiquitous/Mobile Group
Department of Computing Science
University of Glasgow, G12 8QQ, UK
matthew@dcs.gla.ac.uk

ABSTRACT
The application of self-monitoring technologies to the problem of promoting health-related behavioural change has been an active area of research for many years. This paper reports on our investigations into health-related behavioural change within the context of a cardiac rehabilitation programme, and considers the role that self-monitoring currently plays and may play in the future. We carried out semi-structured interviews with nineteen cardiac rehabilitation participants. Our main findings relate to distinctions between implicit and conscious change, tensions between cardiac rehabilitation and everyday life, the importance of self-awareness and self-determination, and an overall reluctance towards unnecessary self-monitoring. In view of these findings, we then offer suggestions as to how self-monitoring technologies coul be designed to suit this particular context of use.

Author Keywords
Self-monitoring, cardiac rehabilitation, physical activity, dietary intake, health-related behavioural change.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. J.3. Life and medical sciences: Health.

General Terms
Human Factors.

INTRODUCTION
The application of self-monitoring technologies to the problem of promoting health-related behavioural change has been an active area of research within CHI and related communities for several years. With the exception of the work relating to dietary monitoring for individuals with chronic kidney disease [33] and diabetes self-management [28,34], the majority of work has focused on developing applications for everyday (non-clinical) use with the general public as the intended user population. We refer to these non-clinical applications as everyday behavioural change applications (EBCA). The most common health-related behaviours being targeted by these EBCAs are physical activity and dietary intake. Although the intended user groups and behaviour of concern varies, one feature that is common to all of the applications is the ability to self-monitor. The methods employed to integrate such behavioural monitoring into these systems range in their technical complexity from manual data entry to distributed sensor networks.

Rather than focusing on behavioural monitoring per se, we are primarily concerned with investigating the process of health-related behavioural change in order to better understand how we can design technologies to support it. A cardiac rehabilitation programme (CRP) offers a relatively controlled context in which to study behavioural change. Occurring over a finite period of weeks, a CRP offers an incentive and focus that may not necessarily exist in 'everyday life'. By investigating this domain we sought to gain an understanding of the potential for technological support within a population with a vested interest in making changes. In particular, we focused on aspects of behavioural change outside of the clinical environment and the interplay between the CRP and everyday life. In some respects any distinction between clinical and everyday change is artificial, as "most of the dynamics of behaviour change take place in patients' private and work settings" [38].

Our main findings relate to distinctions between implicit and conscious change, tensions between cardiac rehabilitation and everyday life, the importance of self-awareness and self-determination, and an overall reluctance towards unnecessary self-monitoring. This work contributes to the existing body of research within HCI on everyday behavioural change applications and self-monitoring technologies by providing insight into the existing practices of a population who are yet to benefit from recent technological innovations. The findings of this study highlights potential barriers to adoption, but also identifies design strategies that we suggest could reorient self-

CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-929-9/10/04.

monitoring technologies to suit the needs of this particular population.

As is often the case when studying populations in extreme circumstances, the insight gained serves to sensitise us to issues that are also of relevance to the mainstream populations. For example, it would be hard to argue that self-determination should not be considered in the design of any behavioural change application. Furthermore, by approaching a clinical domain from the perspective of the patients, we have been able to contextualise health outcomes within the broader landscape of everyday life. By acknowledging that health is one of many competing values, we can now start to design health technology that resonates with that broader context by accounting for those competing values.

BACKGROUND

As was mentioned earlier, the application of self-monitoring technologies to the problem of promoting health-related behavioural change has been an active area of research in HCI for several years. Here we give a brief overview of that work (focussing on physical activity and dietary intake) before reviewing relevant research being done within the cardiac domain.

Persuading Behavioural Change in HCI

Physical activity monitoring tends to take the form of on-body sensing, ranging from carrying mobile phones (e.g., iPhone, Nokia n95) to wearable sensors of varying invasiveness [11,26]. Approaches to monitoring dietary intake include manual data entry, barcode scanning [29], photographing food [34], and the instrumentation of cooking or eating areas [9,10]. While physical activity can now be monitored fairly accurately to a relatively fine granularity, there are outstanding challenges for the practical monitoring of dietary intake.

Although self-monitoring is the most pervasive of behavioural change techniques being embodied in EBCAs, it is most commonly accompanied by others. Physical activity systems tend to combine self-monitoring with *goal-setting* and *social influence*. The simplest approach to determining behavioural goals is to use predetermined goals [l8] or allow the user to define his/her own [37]. While the locus of control remains with the user in the latter approach, a risk of both approaches is that goals that are either too difficult or too easy can fail to inspire change [36]. This problem can be avoided by basing personal step-count goals on the baseline step-counts of each user, which can then be used to calculate static [24] or incremental goals [13]. For the most part, visual feedback is provided to the user when daily goals are achieved; approaches range in complexity from an asterisk annotation [13] to the development of animated characters [25] or plants [14]. Social influence has so far been integrated into such goal-based systems in one of two ways. Competition and social pressure can be introduced by encapsulating behavioural goals within the context of a team-based game [18,25]. Alternatively, peers can benefit from social facilitation and social support by viewing and commenting on each other's progress [13,37].

In contrast, dietary systems tend to combine self-monitoring with *information provision* about nutritional or caloric intake [9,10] or *recommendations* of healthy alternatives [29]. The aforementioned problem of monitoring dietary intake is then further compounded by the challenge of establishing and then maintaining an adequate nutritional database. An alternative approach is to use a camera for data capture and rely on a nutritionist to provide nutritional feedback instead of a database (myfoodphone.com). However, if it is not absolutely necessary to provide nutritional data to the user, this labour-intensive task can be avoided by using the photograph itself as a reflective prompt [34].

Technology Use in Cardiac Rehabilitation

Reflecting the focus of traditional cardiac rehabilitation, technological innovations in this area are grouped around web-based delivery of rehabilitation programmes [21,35,40] and physiological monitoring [22].

Self-monitoring is used as a resource in cardiac rehabilitation to measure effort and progress, both in hospital and at home. Although each CRP differs, they typically involve a range of self-monitoring approaches, varying in technical complexity ranging from continuous ECG monitoring to self-assessment of perceived level of exertion using Borg's Rate of Perceived Exertion Scale [4]. It has been found that long-term use of continuous ECG monitoring can cause reduced self-efficacy for independent exercise when compared to an equivalent programme that gradually weaned patients off ECG monitoring [6]. In addition, the benefit of using technology over manual methods is yet to be conclusively proven for patients who are not considered to be high risk. Over the course of one month, home rehabilitation participants increased their exercise capacity and were able to regulate their own physical exertion at comparable rates regardless of whether they were using self-assessment (Borg scale) or technological measurements [19]. In the long term, there is evidence to suggest that those who continue to self-monitor maintain change for longer than those who do not [2,20]. Unfortunately, both studies employed technology-facilitated monitoring with no manual comparison. It appears that more work is needed to establish the pros and cons of manual and automated monitoring in particular contexts of use.

Web-based CRPs are considered to be a promising method of delivery to cardiac patients in remote rural communities with no access to hospital-based rehabilitation and for populations who under subscribe to existing programmes (e.g., women [35]). The few cardiac web interventions that exist have produced relatively positive outcomes [21]. One example is the "virtual" CRP (vCRP), the design of which was based on standard hospital-based CRP, including

scheduled chat sessions with health professionals, education sessions, and self-reported data capture [40]. In a recent pilot evaluation that compared vCRP with a traditional CRP, the vCRP group experienced clinically significant improvements in risk factors (blood lipids, cholesterol levels, weekly physical activity) and exercise capacity [40]. A larger clinical trial of a similar system yielded somewhat confusing results. Although no statistically significant difference was observed between the web and control group with respect to behavioural or physiological outcomes (apart from weight loss), the web group participants experienced significantly less cardiac-related emergency visits and hospitalisations during the six month trial [35]. The promising clinical outcomes are accompanied by similarly impressive technical acceptance. For example, all of the participants responded "unanimously positive" to the vCRP [40]. Technical literacy was not discussed nor identified as inclusion criteria in the studies presented above. Our reason for highlighting issues of acceptance and technical literacy will become evident in the following section.

THE STUDY

The goal of this study is to gain insight into the process of behavioural change as experienced by cardiac rehabilitation participants, in order to better understand how we can design technologies to support it. More specifically, the work in this paper explores the role that self-monitoring currently plays and may play in the future.

The Cardiac Rehabilitation Programme

The Greater Glasgow and Clyde NHS Citywide Cardiac Rehabilitation Service runs a 10-week cardiac rehabilitation program that is open to all individuals who have recently undergone cardiac surgery or have suffered a cardiac event. Those who accept a place on the rehabilitation program attend a preliminary session where baseline observations are made, tailored physiological and behavioral targets are determined, and a programme is devised. Over the course of the program, participants attend weekly exercise classes and health education sessions. The involvement of friends and family in an individual's rehabilitation program is actively encouraged but at present there are no formal mechanisms through which such involvement is facilitated. Upon completion of the program, participants are given the opportunity to continue attending exercise classes at local community centers.

A Methodological Dilemma

We had originally intended to use a technology probe to carry out our investigations. It was thought that they would provide an ideal medium through which to study such a complex area as behavioural change and the interplay between the cardiac rehabilitation and everyday life, while simultaneously exploring the scope for technological support. The use of technology probes within the health domain is in its infancy, but the approach has successfully been applied to investigating the self-management practices of individuals with diabetes [28] and the nature of communication between young adults with cognitive disabilities and their families [16]; albeit with small participant numbers.

The technology probe that we developed was a collaborative multimedia rehabilitation journal [27], which we had hoped rehabilitation participants would use for the duration of their rehabilitation. While recruiting for the pilot study it became apparent that deploying a lightweight social networking application into this population was not appropriate. Access to technology was particularly low; in one of the rehab classes only 3 of 18 patients had access to the Internet. Even those with access to the Internet were not necessarily comfortable enough with technology to participate. For more details on the pilot study we refer the reader to [27].

After reflecting on the pilot study and consulting with the health professionals involved in the CRP, we decided to continue our investigations without the technology probe; relying instead on semi-structured interviewing. This way, we would be able to explore the original aims of the study alongside questions raised during the pilot with a broader demographic of rehabilitation participants. There are many limitations to interviewing as an investigative technique, the most obvious being the widely acknowledged discrepancy between what people do and what people say they do. Interviewees may also tailor their answers to suit what they think the interviewer wants to hear or to pursue their own agendas [31]. Diary studies are an alternative or additional approach that can minimise the limitations of interviews and provide a richer data set with which to work [7]. However, during the pilot study we had found that recruiting participants at the beginning of rehabilitation created another potential stressor at an already stressful time, and we felt a diary study may have repeated this. A similar argument made it infeasible to apply methods such as ethnographic study. The primary motivation behind our decision to rely on interviews alone was the desire to avoid placing unnecessary demands on the participants. It was necessary to be pragmatic about methodology in this way, in order to work within the constraints of the population and environment being studied.

Method

Participants were recruited at the end of the rehabilitation programme, allowing them to reflect on their experiences. The interviews were performed at the participants' homes, and were structured around topics such as their cardiac event and rehabilitation, health-related behaviours and change, peer-involvement, and technology use. Each interview lasted between 45-90 minutes; the disparity in duration can be explained in part by the fact that some participants had a much greater scope of possible and actual change. In other cases it was more of a matter of participant characteristics e.g., older participants sometimes took longer to explain events. All interviews were audio

recorded and transcribed. Employing inductive analytic methods advocated by Lofland et al. [25], transcripts were initially subjected to open coding, whereby each sentence was analyzed in a process of sensitisation. The emergent codes were then subject to more focused coding, whereby similar codes were grouped together to form categories of phenomena. Similarities and differences were compared and contrasted, and the data was repeatedly revisited. Themes emerged that were then used to structure the data presented in this paper.

The Participants

Nineteen cardiac rehabilitation participants were recruited for the study. The majority of participants were male (n=14). Of the five female participants, three were widowed, one was married and the other was living with her common-law husband. All but one of the male participants were married or living with their common-law wife; the other lived alone but had a long-term partner. One of the married male participants also lived alone. Apart from the gender bias, the participants represented a broad demographic: participants were aged between 43 and 78 (average age= 63.1; s.d. = 10.8) and occupations (and pre-retirement occupations) spanned the manual-professional continuum, including janitor, domestic, policeman, nurse, engineer and labourer.

From a clinical perspective, angina diagnosis had led to seven participants being recruited onto the CRP; the remaining twelve had each had a heart attack. Only three participants were treated non-invasively (only being treated with medication), the majority of participants had undergone an angioplasty to 'unblock' at least one of their coronary arteries. A coronary artery bypass graft was the most invasive procedure that any of our participants underwent; one participant had a double bypass and two others had triple bypasses. The majority of participants had a family history of Coronary Heart Disease. Four participants knew that they had high cholesterol prior to their cardiac diagnosis, one had high blood pressure, two were diabetic—one of who was also clinically obese. Seven participants had no medical history of note. From a behavioural perspective, six participants smoked and five were ex-smokers. Other than one of the smokers who also smoked marijuana, there were no other reports of drug use (apart from prescribed medication). Eight participants drank alcohol regularly. Seven participants considered themselves to have healthy diets prior to their diagnosis.

From a technological perspective, every participant owned a mobile phone; most of them used it daily (13/19). Three participants used their mobile phones weekly and one participant stated infrequent use (monthly). For the most part, the purpose of these phones was to keep in touch with offspring. The remaining two participants had never used their phones. Access to home computers was much more varied. Six participants didn't have a computer at home, five of whom had no experience with computers while the other one used a computer daily at work. The remaining participants (13/19) all had computers at home, although as with the mobile phones, two participants had never used them. All but two of those who owned computers had over four years experience, the remaining two had less than one year's experience. Unsurprisingly, access to and experience with computers was negatively correlated with age.

FINDINGS

Implicit Behavioural Change

The primary behavioural focus of the rehabilitation programme is on improving cardiovascular fitness through participation in physical activity. For the participants, the provision of a structured and supervised exercise programme alleviates the challenge of determining how to go about improving fitness or physical activity levels. All participants spoke positively about the programme, but the subtleties of the benefits that it afforded varied.

For the majority of participants, the programme served as a catalyst for latent intentions. Habits were formed over the course of the programme that, more often than not, participants intended to continue or develop further. In addition to the process of developing a habit by repeating behaviour over a period of time (in this case ten weeks), the guidance and encouragement of the staff promoted self-confidence:

Doing it in the hospital with other people, it gets you into the routine before you set off for the gym on your own. Now I am more prepared and disciplined to go to the gym than if I hadn't [attended the rehabilitation programme]. P6

Interestingly, the pseudo-authoritarian nature of the programme also added weight to its importance:

I said "I might as well, it is only going to do me good. I'm not going to do exercises myself." You know, you get that way... a wee bit lazy. Whereas you're going there, you have got to do it, and that's it. P15

A few participants remained unconvinced about the physical benefit of attending the classes, either because they were already fit and had recovered quickly (P10, P14), or because they felt it was too late for them to get fit (P16, P18). For the most part, they intended to continue with the community–based exercise classes simply because they had been advised to.

In addition to the new source of physical activity that programme attendance provided, many participants had existing patterns of physical activity that they intended to continue, for example, walking a dog. All but three of the remaining participants were hoping to find additional sources of physical activity or had already integrated additional activity into their everyday routine (for example, by extending the morning walk for the paper). The decision of whether to implement additional changes other than those facilitated by programme attendance is discussed in the following sections.

Awareness as a Prerequisite for Conscious Change

Unlike physical activity, which was automatically increased through participation in the rehabilitation programme, the decision to voluntarily extend behavioural change efforts to include other forms of physical activity or other health-related behaviours relied on the individual being aware of a need for change. Awareness either came in the form of self-identification of problem and non-problem behaviours, or through the identification of problem behaviours by health professionals. Here we focus on the self-identification and evaluation of problem behaviours.

Smoking was perhaps the most easily evaluated health-related behaviour in that it is always considered harmful. All of the participants who were still smoking or were in the process of giving up acknowledged that it was a damaging behaviour. In this sense, smoking as a CHD risk factor is unique; each of the others has a continuum of behaviours ranging in degree of perceived healthiness. The following examples illustrate the different metrics used to evaluate various health behaviours. Firstly, participants would refer to being or (more commonly) not being a particular type of person:

I won't say I was active but I wasn't inactive. I play golf so I probably play at least once a week and get a bit of exercise each morning walking to the shop which is half way through the village. I would say it is a good 10 minute walk. A decent day, take the dog a walk, that sort of idea. I work in the garden. So I am not inactive but I was never one for... "oh we'll go for a jog", kinda style. I was not that active a person. P7

Only occasionally were recommended guidelines referred to. In the following example, P15 rejects the recommended guidelines (which he acknowledges he exceeds) in favour of his own subjective measure of whether he is a particular type of drinker:

Well Monday night I go out and play snooker and that is two rounds, so… 6 whiskeys or gins or whatever. Tuesday nothing. Wednesday night I only have maybe 4 gins or something. Thursday I am out with the wife so maybe 7 or 8. Saturday is big… so 9 or 10. I lose count after 9 {laughs}. Sunday is usually a quiet day, so I will maybe just have a pint. So I don't think that I am... I know I'm over the 20 but I'm not what you call a binge drinker.

In other cases, participants would evaluate their lifestyle with respect to whether they participated or abstained from particular sub-behaviours. Perhaps reflecting the success of the recent '5 a day' social marketing campaign in the UK (www.5aday.nhs.uk), consumption of fruit and vegetables was commonly referred to. Others gave examples of vilified behaviours that they abstained from:

My diet and my lifestyle has been pretty good to be honest you know... I don't eat junk food, I cook food. I don't eat packet stuff... I have it now and again but in general I make food from scratch basically and I always have. P12

Arguably, dietary intake is the most complex of health-related behaviours to evaluate and so individuals often singled out particular eating habits. This was most commonly done by those who considered themselves to have relatively healthy diets but sought to make what improvements they could:

I just decided that that was what the problem was, that I eat too many things in between meals. So I thought well if I am going to eat in between meals I am going to eat something that is not bad for me [...] so I went to walnuts which are healthy because they are high in protein and there is nothing else in them [...] I like dates. Walnuts and dates go perfectly together […] I would eat them occasionally before, and now I make a conscious effort to go out and buy them so I have always got them. P0

In other cases, particular behaviours were prioritised because a complete change of dietary intake was deemed unfeasible:

I got it into my head that fat was important [...] I think you can become totally fanatical about the whole thing or... I made the decision that it was fat so therefore that is what I cut out. Everything else I just plod on and eat. P17

The notion that people can take things too far, or that there are acceptable boundaries for change, was a recurring theme throughout the interviews. Indeed, P17 who is quoted above described her sister—who was the only member of the family not to have had a heart attack—as a fanatic who worried too much. Therefore, an awareness of particular behaviours may be a prerequisite of conscious behavioural change but it does not guarantee it. The following section presents the competing values that individuals consider when determining the extent of behavioural change.

How Far is Too Far?

Illustrating various alternatives to health as a motivation for behavioural change, individuals would define what was an acceptable degree of change in terms of taste, interest and enjoyment. Interestingly, those who had undertaken large changes to their dietary habits did not raise taste as a problem—large changes here being defined as changes made to daily meals rather than specific ingredients. Rather, taste was more likely to be blamed for the rejection of one particular food item such as olive oil-based spread or food group such as fruit. For many, abstinence from foods that they enjoyed eating would render behavioural change efforts unsustainable. P10 had dismissed his partner's attempts to persuade him to change his diet, laughingly referring to her as "the food fascist". However, he had changed his diet after consulting with the programme's dietician. When asked what differed between her advice and his partner's, he said that the dietician had been realistic about the changes that he should make and reassured him that making modifications to his diet did not mean his diet had to be bland and boring.

Overall, participants were happy with their lifestyles and so in some cases only wanted to change what was necessary. Participation in the exercise classes was seen as the required change in physical activity, even if they acknowledged that there was scope for more on a day-to-day basis. When asked if he would find it useful to monitor his daily activity levels, P5 responded:

I just can't be bothered with it. It doesn't float my boat to walk about and be fit in that respect. I don't mind going to a gym and you know, sweating it out of me, for an hour and a half or whatever the case may be. In fact I would probably be doing more, hopefully, in that respect.

Apparently at odds with the comment above, P5 had actually integrated a ten-minute walk into his daily routine. The idea of having an allocated time for rehabilitation concerns was echoed by others when discussing information and support seeking practices. Rehabilitation participants are advised by the rehabilitation staff not to become obsessive about their condition, and are encouraged to move on from whatever event led to their participation in the programme. While a few did look up information about their heart and diagnosis on the Internet, the majority were happy with the level of information that they received from the hospital and cardiac rehabilitation teams:

I felt that I have had adequate information provided to me by the hospital and the rehab. That, to me… what is important, they would have given you. You can spend too much time getting yourself into all sorts of things. P6

The variation between participants' acceptable boundaries of change is unsurprising when considering the broad scope of their lifestyles and conditions. Some of those who considered themselves to be healthy eaters went on to make minor changes, while others continued as they had previously. The majority of those with multiple risk factors made moderate changes. Those who expressed a feeling of duty, of being responsible for continuing the good work started by the rehabilitation staff, were more likely to adhere to the behavioural change suggestions of rehabilitation staff than take a more selective approach.

Feeling Progress not Monitoring Behaviour

During the rehabilitation programme, participants learn to measure their heart rate at intermittent points in the exercise class either by manually checking their pulse or by using a heart rate monitor. At week five, if the rehabilitation staff are happy with the participant's condition, the participant is taught how to self-monitor his/her own exertion levels by using the Borg Scale [4]. Instead of monitoring their heart rates at intermittent points in the exercise class, the participants self-categorise their levels of exertion.

Only two of the participants continued to monitor their heart rate after the rehabilitation staff had told them that it was no longer necessary. P8, who had used heart rate monitors before his heart attack when he was training for marathons, used them in order to continue pushing himself while objectively observing his degree of exertion and progress. P0 also checked his heart rate before, during, and after sessions in the swimming pool for similar reasons:

It is easy to do. It is an easy way of accounting for whether there is any sudden change or whether you are actually doing too much. I know what I can take my heart rate up to. As far as exercise is concerned I know what is safe to take it up to. And as long as I keep it at that level, if it goes above that level, I bring it down. If it didn't come back down then I would be concerned.

Unlike P8, P0 chose to self-monitor manually. Like the pilot-study participants who had already established manual self-monitoring routines [27], he did not see the benefit in using technology to do the same task:

OK you can buy a pulse monitor and put it on your wrist or put it around your chest. What is the point if I can take my pulse myself? It's not difficult. I don't see the point in technology if it is just replacing something that you could do yourself just as easily.

Additionally, he used the objective measure of effort alongside how he felt that day: what sort of day he was having and whether he was tired or not. Measuring progress was primarily done by feel, i.e. how an individual felt during exercise or on a day-to-day basis. P1, for instance was aware that she felt worse during her exercise class on a Monday and put that down to the five-day gap between classes and was seeking an additional source of exercise to narrow the gap. Her overall physical goal was to get through her exercise classes pain-free. Feedback came in small advances, such as losing an inch around the waist or being able to get up from the chair without a struggle.

Perhaps reflecting the prescriptive nature of the rehabilitation programme and the broader focus of many of the rehabilitation participants, the overall attitude towards self-monitoring anything other than how they were feeling was that it simply was not required. Several participants added that they would self-monitor if they were told to do it, or if asked to do so for a study, but it was not something they could see the benefit in. Like P8, P7 had used a heart rate monitor when he was younger when training for football, but said that it was unnecessary now since he had no intention of pushing himself.

DISCUSSION

One of the motivating factors behind our investigation of cardiac rehabilitation as a behavioural change domain was that we wanted to explore the dynamics of behavioural change within a population who had a vested interest in making such changes. The underlying assumption was that those who are diagnosed with a cardiac condition would want to make behavioural changes. To a degree, this assumption was found to be true. By participating in the cardiac rehabilitation programme, individuals automatically introduced two hours of physical activity into their weekly routine. The vast majority of participants expressed a keen

intention to continue attending exercise classes that were provided by the rehabilitation service at local community centres. However, attitudes towards making additional behavioural changes varied greatly between participants. This reflected both the broad variety of lifestyles among the participants and their willingness to change. Some participants were already living what would be considered to be relatively healthy lifestyles while others could identify multiple areas of excess. Some participants undertook radical changes, while others focused on a single behaviour. The degree of change was determined by what the individual considered to be acceptable boundaries of taste, enjoyment, or interest. Furthermore, perhaps reflecting the urges of the cardiac rehabilitation staff not to become obsessed about their condition, and the attitude of doing what the clinicians advise is all that is required, the time spent in the rehabilitation class was seen as allocated heart time. Once over the initial recovery period, further reflection on the cardiac condition and health-related behaviours was considered excessive.

Reflecting on these findings, here we consider the merits of self-monitoring technologies and offer recommendations as to how they can be designed to support the current practices of cardiac rehabilitation participants. In particular we consider the role of self-awareness and personal choice when determining the extent of change, and reflect on the nature of the shifting focus of rehabilitation participants from overcoming the challenges of rehabilitation to getting back to 'normal life'.

Supporting Self-Assessment of Behavioural Habits

Apart from when change is implemented subconsciously, as was done through participation in the cardiac rehabilitation programme, behavioural change depends on the individual considering a particular behaviour to be problematic. During this study we observed how participants placed themselves and their behaviours on a continuum when determining whether and how much change was necessary. To do so relies on the self-assessment of behavioural habits, of which there are two well known limitations: firstly people can over- or underestimate frequency of participation [17,32], and secondly misconceptions of how healthy or unhealthy particular behaviours are can lead a person to underestimate the unhealthiness of their habits [23]. It can be presumed that such misconceptions also lead to similar overestimation, but this is rarely featured as a problem in the health literature.

The objective measure of behaviour that self-monitoring technology affords is obviously suited to addressing the problem of over- and underestimation. In contrast, overcoming the second limitation of self-assessment is a less obvious application of self-monitoring technology. However, we suggest that this is very much a HCI research question: how can we present the (behavioural) data to the user in such a way that he or she can draw informed conclusions about the need to make behavioural changes?

When seeking to address this issue, we suggest *designing for clinical and social contextualisation*. The need for both clinical and social contextualisation was illustrated in this study by the somewhat conflicting instances of perceived importance and authority of clinical recommendations and rejection of advice based on an individual's subjective measure of healthiness. There are already examples of clinical and social contextualisation within the existing body of work within CHI and related domains. As we saw earlier, dietary monitoring systems typically augment monitored data with information regarding nutritional value [9,10], while comparable systems that monitor physical activity tend to socialise monitored activity levels, enabling comparison and competition between peers [13,18,24,37]. When considering how to further develop existing methods, clinical contextualisation could provide explanations of reasons behind the guidelines and consequences of actual behaviour, while other potential sources of social contextualisation include people of varying age groups, gender, and national averages. Within the context of a cardiac rehabilitation programme *it is likely that personalised benchmarks, rather than the generic national guidelines and averages, would be necessary that are sensitive to the individual's physiological status and stage of rehabilitation*.

Supporting Self-Determination of Behavioural Change

Although changes to physical activity levels were embraced and adopted implicitly by enrolment and adherence to the rehabilitation programme, participants were quite candid about their decisions as to whether or not to implement additional changes. In the previous section we suggested that self-monitoring technology be developed to support self-assessment of behavioural habits such that the individual can make an informed choice. There are subtle differences between developing to promote informed choice and developing to promote behavioural change. Designing to promote informed choice recognises that an individual may well decide not to implement behavioural changes. It could well be argued that this matter of choice is a basic human right, and it is especially pertinent in cardiac rehabilitation. A common psychological reaction to suffering a cardiac event is a feeling of lacking control over one's own life [3,39]. Facilitating the ability to retake control of one's life is fundamental to the process of cardiac rehabilitation. We therefore suggest that designing explicitly to support the self-determination of behavioural change will not only increase the likelihood of the technology being adopted, but will also complement psychosocial aspects of cardiac rehabilitation that are often overlooked in favour of physiological and behavioural outcomes.

Three broad recommendations as to how technology could be designed to support self-determination can be derived from the findings of this study. At the very least, *systems should allow for partial changes* and furthermore *not represent incomplete changes as failure*. Examples of

partial change observed during this study include cutting down alcohol intake rather than stopping altogether, or focussing on one particular food item to avoid or integrate into the diet. The suggestion to avoid representing incomplete change as a failure is reminiscent of the observation made by Consolvo et al. [14] that negative visualisations in Fish'n'Steps [24] might have resulted in negative motivational and behavioural outcomes. Here, while we obviously want to avoid demotivating behavioural change, our primary concern is on avoiding imposing externally defined measures of progress on the individual. Participants often had multiple habits that were considered to be behavioural risk factors for heart disease. In one case a participant made radical changes to his lifestyle, but it was more common for an individual to focus on one prioritised health-related behaviour. Indeed, the cardiac literature advocates promoting manageable change rather than striving to implement multiple behavioural changes that more often than not simply overwhelm the individual and increase the likelihood of failure [39]. Therefore our second recommendation is to *facilitate the prioritisation of behaviours in cases where there is the potential to make multiple behavioural changes*. The process of prioritisation may be automated, or could be performed by health professionals or the individual themselves. What is important to remember with respect to supporting self-determination is that *the individual should be able to override any priorities that he or she did not identify*.

Finally, while we do not want to enforce externally defined behavioural goals on cardiac rehabilitation participants, we do not want to delimit the opportunity for making additional changes. We therefore recommend that designers *make non-prioritised behavioural information available secondarily, so as to allow for potential developmental exploration and incremental changes*. For example, if an individual is choosing to focus on reducing salt intake, any ranking of nutritional value could be made primarily on the basis of the salt content of the food items, while also making additional nutritional information accessible.

Reorienting Self-Monitoring Technology

At this point we should be mindful of the reluctance of the majority of participants with regard to unnecessary self-monitoring, where necessity relates both to the clinical need for self-monitoring, and to the use of technology "for technology's sake". We do not suggest that all technology developed for this population will be rejected; throughout the UK, cardiac rehabilitation programs are developing online programmes for those who cannot or do not want to attend rehabilitation in-person. However, the question remains as to how we should design for a population that is not comprised of early adopters [30] or does not include them at all. On the one hand, there is the argument that 'users don't know what they want', i.e. that people cannot always envisage how technology could be useful to them, and as such innovation should not be constrained by a lack of perceived value before value can truly be appreciated. On the other hand, we should be wary of what Chandler [8] refers to as the technological imperative, the attitude "that because a particular technology means that we can do something (it is technically possible) then this action either ought to (as a moral imperative), must (as an operational requirement) or inevitably will (in time) be taken", and that "our task as users is to learn to cope with it".

Ackerman [1] identifies a similar argument against the significance of the gap between the nuances of social activity and the limitation of current technical capabilities to support such social activity, but goes on to make the counter argument that, "a central premise of HCI is that we should not force users to adapt." The question of how to remain sensitive to the needs of a population while allowing for technological innovation is not one that can be conclusively answered within this paper. We advocate approaching the problem space from the perspective of the individuals themselves. This is not a novel suggestion, but the core of Value-Centred HCI [12].

When considering this issue with respect to the development of self-monitoring technologies for cardiac rehabilitation participants, here we suggest three ways in which existing technologies could be reoriented in order to better fit the existing attitudes and values of participants observed in this study.

Instead of aiming to prompt behavioural change, self-monitoring technologies could be applied to the problem of validating existing behavioural change efforts. In other words *design for behavioural validation* rather than behavioural monitoring. For those who have integrated additional walks into their daily or weekly routines, it could be used to verify that they are walking fast or far enough to contribute to their cardiovascular health. For those making dietary changes, new foodstuffs could be compared to old items to verify that the change is nutritionally beneficial.

Our findings highlighted that an individual's primary focus is not necessarily health or the behavioural change that he/she is undertaking. In consideration of the intermittent focus of participants on behavioural change, as was illustrated by the concept of having an allocated 'heart time', we suggest that technology *provides a referential service rather than a continuous presence*. Furthermore, we should be sensitive to the decreasing focus that cardiac rehabilitation and cardiac condition must have over time if a participant is to 'get back to normal' and avoid becoming preoccupied or even obsessed. As such, technologies should be designed to *support varying degrees of engagement and allow for gradual disengagement*.

CONCLUSION

This paper presented our investigations into the process of health-related behavioural change as experienced by individuals who had completed or were coming to the end of a cardiac rehabilitation programme. Our results highlighted the complex nature of behavioural change

following a cardiac event: distinctions between implicit and conscious change, tensions between cardiac rehabilitation and everyday life, and the importance of self-awareness and self-determination. This study has highlighted potential barriers to the adoption of self-monitoring technology, but also identified design strategies aimed at reorienting technologies to suit the needs of this population. This work complements existing work within CHI and related communities by increasing our understanding of a population that are yet to benefit from recent innovations in this field, identifying ways to further develop existing approaches and identifying new directions for future research. In particular, by acknowledging that health is one of many competing values, we can now start to design health technology resonates with the broader context of everyday life by accounting for those competing values.

As with any research that relies on the voluntary participation of human subjects, generalisation from our findings is constrained by the self-selective nature of study participants. We acknowledge this limitation, and we can only speculate as to whether the mindset and experience of the people who were willing to participate are representative of those who decided not to participate. That said, we would argue that our decision to use interviews encouraged the recruitment of an acceptably representative sample of the rehabilitation population. In an earlier section we commented that a primary motivation behind the use of interviews was to employ a method that placed as low a demand as possible on the study participants. A secondary motivation was to practice inclusive research. We are aware that it is not common within CHI to employ interviews alone, although there are recent examples of interview-based studies that investigate the use of specific technologies [5,15]. We suggest that if we, as a community, only study existing users and individuals who are able or inclined to participate in high-tech or high-demand studies then we create a systemic bias in our findings, theories and designs. In future work we hope to refine our methodology for working with people who are often unwilling or unable to participate in more traditional HCI processes of evaluation and design, and to further explore the research and design directions that were presented in this paper.

ACKNOWLEDGMENTS

We sincerely thank the study participants for allowing us into their homes and sharing their experiences. We also thank the Greater Glasgow and Clyde NHS Citywide Cardiac Rehabilitation Service health professionals who provided invaluable input, along with Frances Mair and Phil Gray. This work was funded by a UK EPSRC PhD studentship.

REFERENCES

1. Ackerman, M. The Intellectual Challenge of CSCW: The Gap Between Social Requirements and Technical Feasibility. *HCI*, 2000, 15, (2-3), 179-204
2. Arrigo, I., Brunner-LaRocca, H., Lefkovits, M., Pfisterer, M., and Hoffmann, A. Comparative outcome one year after formal cardiac rehabilitation: the effects of a randomized intervention to improve exercise adherence. *Eur J Cardiovasc Prev Rehabil*, 2008, 15, (3), 306-311
3. Astin, F., Atkin, K., and Darr, A.: Family support and cardiac rehabilitation: A comparative study of the experiences of South Asian and White-European patients and their carers living in the United Kingdom. *Eur J Cardiovasc Nurs*, 2008, 7, 43-51
4. Borg, G. *Borg's perceived exertion and pain scales*. (Human Kinetics, 1998)
5. Brown, B. and Barkhuus, L. The television will be revolutionized: effects of PVRs and filesharing on television watching. *Proc. CHI 2006*, ACM Press (2006), 663-666
6. Carlson, J.J., Norman, G.J., Feltz, D.L., Franklin, B.A., Johnson, J.A., and Locke, S.K. Self-efficacy, psychosocial factors, and exercise behavior in traditional versus modified cardiac rehabilitation. *J Cardiopulm Rehabil*, 2001, 21, (6), 363-373
7. Carter, S. and Mankoff, J. When participants do the capturing: the role of media in diary studies. *Proc. CHI 2005*, ACM Press (2005), 899-908
8. Chandler, D. Technological or Media Determinism. 1995, http://www.aber.ac.uk/media/Documents/tecdet/tecdet.html
9. Chang, K.-h., Liu, S.-y., Chu, H.-h., Hsu, J.Y.-j., Chen, C., Lin, T.-y., Chen, C.-y., and Huang, P. The Diet-Aware Dining Table: Observing Dietary Behaviours over a Tabletop Surface. *Proc. Pervasive 2006*, Springer (2006), 366-382
10. Chi, P., Chen, J., Chu, H.-h., and Lo, J. Enabling Calorie-Aware Cooking in a Smart Kitchen. *Proc. Persuasive 2008*, Springer (2008), 116-127
11. Choudrey, T., Borriello, G., Consolvo, S., Haehnel, D., Harrison, B., Hemingway, B., Hightower, J., Klasnja, P., et al. The Mobile Sensing Platform: An Embedded System for Capturing and Recognizing Human Activities. *Pervasive Computing*, 2008, 7, (2), 32-41
12. Cockton, G. Value-centred HCI. *Proc. NordiCHI 2004*, ACM Press (2004), 149-160
13. Consolvo, S., Everitt, K., Smith, I., and Landay, J. Design Requirements for Technologies that Encourage Physical Activity. *Proc. CHI 2006*, ACM Press (2006), 457-466
14. Consolvo, S., McDonald, D., W., Toscos, T., Chen, M., Y., Froehlich, J., Harrison, B., Klasnja, P., LaMarca, A., et al. Activity sensing in the wild: a field trial of ubifit garden. *Proc. CHI 2008*, ACM Press (2008), 1797-1806
15. Dawe, M. Desperately seeking simplicity: how young adults with cognitive disabilities and their families adopt

assistive technologies. *Proc CHI 2006*, ACM Press (2006), 1143-1152

16. Dawe, M.: Reflective Design-In-Use: Codesigning a Remote Communication System with and for Individuals with Cognitive Disabilities and their Families. Unpublished Thesis, Univeristy of Colorado, 2007, http://l3d.cs.colorado.edu~meliss/research/dissertation/MelissaDawePhDDissertation.pdf
17. Dwyer, J., Picciano, M., and Raiten, D. Estimation of Usual Intakes: What We Eat in America-NHANES. *J Nutr*, 2003, 133, (2), 609S-623S
18. Gasser, R., Brodbeck, D., Degan, M., Luthiger, J., Wyss, R., and Reichlin, S. Persuasiveness of a Mobile Lifestyle Coaching Application using Social Facilitation. *Proc. Persuasive 2006*, Springer (2006), 27-38
19. Ilarraza, H., Myers, J., Kottman, W., Rickli, H., and Dubach, P. An evaluation of training responses using self-regulation in a residential rehabilitation program. *J Cardiopulm Rehabil*, 2004, 24, (1), 27-33
20. Izawa, K.P., Watanabe, S., Omiya, K., Hirano, Y., Oka, K., Osada, N., and Iijima, S. Effect of the self-monitoring approach on exercise maintenance during cardiac rehabilitation: a randomized, controlled trial. *Am J Phys Med Rehabil*, 2005, 84, (5), 313-321
21. Kuhl, E.A., Sears, S.F., and Conti, J.B. Internet-based behavioral change and psychosocial care for patients with cardiovascular disease: A review of cardiac disease-specific applications. *Heart Lung*, 2006, 35, (6), 374-382
22. Kumar, S., Kambhatla, K., Hu, F., Lifson, M., and Xiao, Y. Ubiquitous computing for remote cardiac patient monitoring: a survey. *Int J Telemedicine Appl*, 2008, (4), 1-19
23. Lechner, L., Brug, J., De Vries, H., van Assema, P., and Mudde, A. Stages of change for fruit, vegetable and fat intake: consequences of misconception. *Health Educ*. Res., 1998, 13, (1), 1-11
24. Lin, J., J., Mamykina, L., Lindter, S., Delajoux, G., and Strub, H., B. Fish'n'Steps: Encouraging Physical Activity with an Interactive Computer Game. *Proc. Ubicomp 2006*, Springer (2006), 261-268
25. Lofland, J., Snow, D., A., Anderson, L., and Lofland, L., H. *Analyzing Social Settings: A Guide to Qualitative Observation and Analysis.* (Wadsworth Publishing, 2005)
26. Lukowicz, P., Hanser, F., Szubski, C., and Schobersberger, W. Detecting and Interpreting Muscle Activity with Wearable Force Sensors. *Proc. Pervasive 2006*, Springer (2006), 101-116
27. Maitland, J., and Chalmers, M. *Probe*lems: reflecting on a technology probe into peer involvement in cardiac rehabilitation. *Proc. Pervasive Health 2009*, IEEE (2009)
28. Mamykina, L., Mynatt, E., D., and Kaufman, D., R. Investigating Health Management Practices of Individuals with Diabetes. *Proc. CHI 2006*, ACM Press (2006), 927-936
29. Mankoff, J., Hsieh, G., Hung, H., C., Lee, S., and Nitao, E. Using Low-Cost Sensing to Support Nutritional Awareness. *Proc. Ubicomp 2002*, Springer, 371-376
30. Moore, G.A. *Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers*. (Capstone, 2001)
31. Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., and Carey, T. *Human-Computer Interaction*. (Addison-Wesley, 2000)
32. Sallis, J.F., and Sealens, B.E. Assessment of Physical Activity by Self-Report: Status, Limitations, and Future Directions, *Res Q Exerc Sport*, 2001, 71, S1-14
33. Siek, K. A., Connelly, K. H., Rogers, Y., Rohwer, P., Lambert, D., and Welch, J., L. When do We Eat? An Evaluation of Food Items Input into an Electronic Food Monitoring Application. *Proc. Pervasive Health 2006*, IEEE (2006)
34. Smith, B.K., Frost, J., Albayrak, M., and Sudhakar, R. Integrating glucometers and digital photography as experience capture tools to enhance patient understanding and communication of diabetes self-management practices. *PUC*, 2007, 11, (4), 273-286
35. Southard, B.S., Southard, D.R., and Nuckolis, J. Clinical Trial of an Internet-based Case Management System for Secondary Prevention of Heart Disease. *J Cardiopulm Rehabil*, 2003, 23, (5), 341-348
36. Strecher, V.J., Seijts, G.H., Kok, G.J., Latham, G.P., Glasgow, R., DeVellis, B., Meertens, R.M., and Bulger, D.W. Goal Setting as a Strategy for Health Behavior Change. *Health Educ Behav*, 1995, 22, 190-200
37. Toscos, T., Faber, A.M., Connelly, K.H., and Upoma, A.M. Encouraging Physical Activity in Teens: Can technology help reduce barriers to physical activity in adolescent girls? *Proc. Pervasive Health 2008*, IEEE (2008)
38. Verheijden, M.W., Bakx, J.C., van Weel, C., Koelen, M.A., and van Straveren, W.M. Role of social support in lifestyle-focused weight management interventions. *Eur J Clin Nutr*, 2005, 59, (1), 179-186
39. Wingham, J., Dalal, H.M., Sweeney, K.G., and Evans, P.H. Listening to patients: choice in cardiac rehabilitation. *Eur J Cardiovasc Nurs*, 2006, 5, (4), 289-294
40. Zutz, A., Ignaszewski, A., Bates, J., and Lear, S.A.: Utilization of the Internet to deliver cardiac rehabilitation at a distance: a pilot study. *Telemedicine and e-Health*, 2007, 13, (3), 323-3