

Influencing Health-Related Behaviour with Wearable Cameras: Strategies & Ethical Considerations

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ABSTRACT

BACKGROUND: The growing global burden of non-communicable diseases makes it important to monitor and influence a range of health-related behaviours such as diet and physical activity. Wearable cameras appear to record and reveal many of these behaviours in more accessible ways. However, having determined opportunities for improvement, most health-related interventions fail to result in lasting changes.

AIM: To assess the use of wearable cameras as part of a behaviour change strategy and consider ethical implications of their use.

METHODS: We examine relevant principles from behavioural science theory and consider the way images enhance or change the processes which underpin behaviour change. We propose ways for researchers to instigate the use of and engagement with these images to lead to more effective and long-lasting behaviour change interventions. We also consider the ethical implications of using digital life-logging technologies in these ways. We discuss the potential harms and benefits of such approaches for both the wearer and those they meet.

DISCUSSION: Future behaviour change strategies based on self-monitoring could consider the use of wearable cameras. It is important that such work considers the ethical implications of this research and adheres to accepted guidelines and principles.

Author Keywords

Wearable cameras; behaviour change; technology theory

ACM Classification Keywords

H.1.2 User/Machine Systems; H.5.1 Multimedia

Information Systems; J.3 LIFE and MEDICAL SCIENCES

General Terms

Human Factors; Design; Theory

THE IMPORTANCE OF HEALTH-RELATED BEHAVIOUR AND THE ROLE OF TECHNOLOGY

Non-communicable diseases accounted for the majority of the 52.8 million deaths that occurred worldwide in 2010[37]. The good news is that health professionals believe that this tremendous disease burden and the associated annual death toll could be significantly reduced. The World Health Organization has identified 4 lifestyle factors as targets in this regard[39], namely:

- reducing smoking,
- reducing alcohol consumption,
- improving diet, and
- increasing physical activity.

However, motivating the wider population to modify their behavior to adopt these factors is not easy. Currently a spectrum of approaches are used including national health policies, extensive public communication and a variety of environmental design factors. However, there is still a large opportunity to engage with more individuals.

Indeed, individual-focused interventions which target the needs and activities of individuals rather than the population at large have been shown to be effective, but of course the reach and impact of these are typically limited. However, with advances in technology individual-focused interventions are increasingly feasible. For example mobile-phone based behavioural support solutions are potentially available to over 70 percent of the global population[30]. The potential of technology to facilitate behaviour change has been supported by a recent Lancet series focusing on physical activity interventions and endorsing their application[27].

One category of technology which has long been the subject of research studies but which is now becoming increasingly established in the mass-market is wearable computing. As digital processing elements, storage, display and interaction technologies become smaller, cheaper and lower-powered, we are seeing an increasing number of devices which are designed to be worn by a user – such as smart watches and motion-sensing activity monitors.

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Wearable technologies such as these have the unique potential to continuously and objectively monitor certain health-related behaviours and to analyse the information they collect to determine and immediately suggest alternative behaviours to the wearer.

Previous work has shown how wearable cameras – devices which periodically capture and record images taken from the wearer’s point of view – may be used to record health-related behaviours[10]. We believe that they can also play a role in influencing the wearer’s behaviour, and the devices become more widely available, they have the potential to have a large impact across the global population.

PRIOR USE OF WEARABLE CAMERAS TO INFLUENCE BEHAVIOUR

Recent research applications using visual technologies in the health sciences has been limited to the environment of cognitive rehabilitation and case studies using wearable cameras as memory aids[4,26]. To date, there are no prominent examples of wearable cameras facilitating lifestyle related behaviour change[4,22]. However, we believe that wearable camera technology could form the basis of a powerful incentive for individuals to adapt their health-related behaviour. This thesis is based on two observations. Firstly, images from wearable cameras can be used to validate and enhance the way we traditionally measure health related behaviours[10], as evidenced by multiple studies currently underway by researchers across the world. Secondly, their ability to objectively measure an individual’s behaviour offer the opportunity to provide timely, contextual, tailored and, personal feedback information about behaviours to individuals to support behavior change.

Wearable camera data is engaging to review[5,22,35], and identifies a broad range of behaviours[10]. Wearable cameras, having similar properties to wearable sensors, may offer the ability to address core components of successful behaviour change interventions[20,29] such as self-monitoring and goal setting. The use of modern sensors reduces user burden through providing continuous and automated feedback on performance to build motivation and confidence[2,36].

Wearable cameras do have limitations of course. Individuals may be unwilling to use wearable cameras due to privacy concerns[23,24,32] and this may act as a barrier to participation in an intervention [3]. Additionally, third parties can be unknowingly or unwillingly recorded. Therefore interventions using wearable cameras may have to be short in duration, rather than involving wear over extended periods of time. Consequently, if intervention wear time is short, a “Hawthorn” effect may occur.

We feel it is time for researchers to explore the utility and efficacy of wearable cameras and build the theoretical constructs to promote health improving lifestyle behaviours

using wearable technology. The aim of this paper is to consider the potential role and ethical implications of using wearable cameras as tools in lifestyle health interventions. As part of this process we discuss established strategies for behaviour change and consider how wearable cameras might add value to these strategies.

STRATEGIES FOR INFLUENCING HEALTH BEHAVIOUR CHANGE WITH WEARABLE CAMERAS

THE THEORY

Many previous technology-based interventions have not been grounded in health behaviour change theory, which limits the ability to scale them and transfer them across populations[29]. The fast pace of market dynamics and public adoption of the technology has a tendency to outstrip associated research investigating effectiveness of specific technologies.

We follow a behavioural science-informed design process[18] influenced by various mechanisms identified as important in behaviour change. For each of these, we have considered how wearable camera technology has the potential to contribute to behavioural change, as listed in Table 1. Relevant principles include self-determination theory, the health belief model and social cognitive theory. Some of the common intervention objectives identified from these theories include: (i) promoting an individual’s competence and capability; (ii) providing opportunities to change behaviour with motivation; and (iii) compliance, maintained through self-identified solutions, ideally involving social interaction[31][21]. Michie and colleagues’ systematic review of behavioural interventions has identified that the most effective strategies for behaviour change include; self-monitoring, prompting intention formation, goal setting, goal review and facilitating behaviour reinforcement through feedback [20].

Table 1: Strategies previously-identified as successful in motivating behaviour change and how reviewing wearable camera images could realise these.

<i>Behaviour change strategy</i>	<i>How wearable cameras can help</i>
Increasing awareness	Wearable cameras can record a first-person view of a variety of health behaviours which can then be played back to the individual
Increasing fun & enjoyment	Reviewing wearable camera images has been demonstrated as a fun and engaging process
Increasing motivation	Reviewing engaging wearable camera images may in turn increase the level of importance an individual places on behaviour change, or reinforce commitment to the behaviour thereby

	increasing their motivation
Increasing confidence	Selectively reviewing episodes of behavioural successes can be repeated until behavioural goals are achieved
Reviewing Progress	Wearable camera data can be manipulated to measure behaviours of interest[9,11] which can be fed back to users, for example via smartphones

In the rest of this section we present a series of examples that demonstrate more completely the potential utility of wearable technologies for each of the mechanisms we have identified. We consider both theoretical targets such as competence and capability, and also the strategies of goal setting and self-monitoring. Wearable cameras facilitate self-monitoring where feedback from the resulting visual diary becomes a tool for motivational interviewing to allow goal review and promote confidence to achieve behavioural goals[30].

INCREASING AWARENESS

Wearable cameras are small, increasingly discrete, allow automatic, continuous, and objective tracking of lifestyle health behaviours[10]. They have the ability to be “always-on” and record approximately 2000 first-person point of view images per day[14], or video[19], with storage capacity for over 10 days. They can capture a wide variety of lifestyle behaviours, such as sedentary behaviour[17], active travel[15], a range of physical activities and social context[10], even nutrition related behaviour[25]. The combination of feasibility of wear and objective behaviour measurement equates to rich personal data, where behaviours are captured with the addition of contextual detail of social and environmental setting[10]. This is an advance on past behavioural self-monitoring techniques that involved burdensome methods such as periodic diary keeping. Technology based self-monitoring allows individuals to continuously and independently track their own behaviour. In turn, individuals tracking a behaviour of interest may become more aware and make a conscious effort to alter this given behaviour.

Self-monitoring helps raise awareness of participants’ current behavioural patterns and also provides information about antecedents of the behaviour and the social context. These attributes can not only help participants reflect and learn how to recreate conditions when the behavioural target was successfully achieved, but also make unconscious choices conscious. Identifying successful engagement in a given behaviour is positively reinforcing which in turn increases confidence, or self-efficacy promoting competence to repeat the action given the opportunity. Wearable cameras not only remove a barrier to self monitoring but through rich behavioural data can help promote self-awareness and self-efficacy to overcome barriers to behaviour change.

INCREASING FUN & ENJOYMENT

Reviewing wearable camera images appears to be a fun and engaging experience[5,22,35], which may provide individuals with additional impetus to review their behaviour. This creates the potential for a cycle of prompting image review (reviewing behaviour), personal feedback on behaviour, personal satisfaction and enjoyment creating motivation to maintain the action and repeat the cycle. Or alternatively, it may provide social reward through image sharing and commentary. Recall, reflection and reminiscence through these retrospective actions may influence the reinforcement of behaviours[32]. Furthermore, review of wearable camera images appears to support autobiographical memory[4,33] which may include emotional association. This is supported by Caprani and colleagues who have demonstrated that older adults enjoy using touchscreen software to independently reflect on wearable camera images [8]. These engaging experiences may entice individuals to reflect on their behaviours more frequently than for example diaries, providing self-monitoring benefits as previously described.

INCREASING MOTIVATION

Wearable camera images can help individuals reflect on their lifestyle behaviours, which may be a sobering experience[9]. A physical activity intervention may be framed around a challenge of “sit less, move more” and the ratio of sitting to activity may be visually stark. During motivational interviewing reviewing these images may facilitate more relatedness of image to personal behaviour and realization of the need to self-regulate a behaviour. For example, therapist health care providers have found that images drawn from participants’ real lives can support productive conversations and offer greater insight during therapeutic sessions, by constructing cognitive dissonance between behaviour and value[7]. However, as discussed review of wearable camera images also has the potential to induce positive mood change through emotional association[22]. Therefore reviewing these engaging images may in turn increase the level of importance an individual places on behaviour change, in a motivational interview model, this may include acknowledging the need for change, or reinforce commitment to the behaviour thereby increasing their motivation.

INCREASING CONFIDENCE

Wearable camera images can identify a range of lifestyle behaviours which could be shown to the user[10]. Selectively reviewing episodes of behavioural successes can lead to mastery learning where feedback on successful performance can be fed back to refine repeated successful performance until behavioural goals are achieved. In the example of physical activity, a visual diary providing a record of daily activity may have many example images of an individual already engaging in light to moderate activity. Feedback on the images has the potential to positively reaffirm these behaviours but also identify opportunities to increase moderate activity. It may be that the individual did

not realise that taking the stairs or walking from the train station were moderate activities. Structured feedback relating to target behaviours may increase the individual's confidence of further behaviour engagement in the future.

REVIEWING PROGRESS

Wearable camera data can be used to measure behaviours of interest[9,11] which can be fed back to users via smartphone technologies. The selected images can be used to review attainments in relation to behavioural goals and to set new goals. Reviewing progress towards goals and goal attainment visually is expected to be more engaging and therefore reinforcing, compared to just text feedback. The automated processing could be achieved through computer vision techniques automatically identifying behavioural episodes from wearable camera images[9], though this work requires further maturity. Wearable camera data can also be aligned with other sensors to identify behaviour achievements, such as accelerometers[11]. Setting specific behaviour targets and regularly comparing progress against these targets or goals is a technique associated with successful behaviour change[20].

ETHICAL CONSIDERATIONS OF USING WEARABLE CAMERAS TO INFLUENCE BEHAVIOUR CHANGE

It is important to consider the ethical implications of using any new technique or intervention in health research. This section will explore the issues related to health behaviour interventions using SenseCam or similar techniques.

For the issues of health behaviour interventions, we generally consider two aspects of the intervention; (1) data collection and (2) engagement with the data. Data collection refers to wearing the camera to record the daily life or behaviours of interest. Engagement with the data refers to viewing the images and engaging in the ways described in the previous section. Of course these aspects may overlap, run concurrently or be iterative. We use these considerations to inform recruitment, consent and participant information and protocols. Table 2 summarises the issues that we will now discuss as relevant to constructing a behaviour change intervention employing wearable cameras. Tailored, meaningful, participatory and educational approaches which adapt to these issues may be considered more ethical.

DATA COLLECTION

In 2013 we proposed a framework for ethical use of first person image capture in observational health research[16]. This framework was based on the principalist approach to ethics and built on existing guidelines for photographic methods developed by Prosser et al[28]. We use this same principalist approach in considering behavioural interventions. In our previous guidelines we focused on preserving participant autonomy through informed consent that made potential issues surrounding privacy and third party relationships very clear to participants. The goal was to minimise burdens and potential harms to participants and

third parties during the data collection phase. We feel these principles apply equally to the data collection phase of an intervention and should be followed accordingly.

Table 2: Researchers intending to investigate and utilise image based health behaviour interventions should consider the following ethical issues.

<i>Ethics consideration</i>	<i>Description of ethics consideration</i>
Loss of confidentiality	Stigmatisation or loss of confidentiality of research participants through identification of their involvement in the intervention by wearing the camera in public.
Harming confidence	Potential harms to confidence, self-efficacy and motivation, without known treatment or mitigation. Participant responses are likely to be differential and in some cases fatalistic.
Blaming others	Blame for certain behaviours may be wrongly or harmfully assigned to third parties (e.g. family or friends of participants).
Inappropriate image sharing	Certain methods could lead to images shared with long term consequences. There is also the risk of inappropriate image sharing. These images may contain unknowing or unwilling third parties.
Equitable access challenges	Equitable access and resource allocation may be challenging for such interventions.

However, in comparison to observational research, a health intervention may pose an additional risk of stigmatising or breaching the confidentiality of the participant. An obese patient referred to a diet or exercise intervention may draw attention to this fact by wearing the camera at work, school or in public. To protect participant autonomy, they should be made fully aware of this possibility at informed consent and reminded they can remove the camera whenever it makes them feel uncomfortable. While this risks data loss, the period of missing images could still be an important prompt or area for discussion with the researchers at analysis.

ENGAGEMENT WITH THE DATA

During observational health research with wearable cameras, the data analysis and dissemination does not pose substantial risk to participants if proper data security and storage protocols are followed. The images are usually aggregated to reveal behaviours, results are anonymised and images are not needed to represent the results. While

participants can review and delete their images, they are not asked to reflect on the behaviours or their implications. We consider this phase of the research as benign to participants. However, this is not necessarily the case when using these images in behavioural interventions. There is risk of maleficence, causing harm or burden, in asking participants to engage with the images and reflect on their own behaviour.

It is not clear what will happen to participant efficacy, self-confidence or motivation if they are objectively shown to have low levels of healthy behaviours or high levels of unhealthy behaviours; particularly if this is greatly at odds with their own self-perception. This cognitive dissonance is often the goal of behaviour change interventions and would be the very strength of the camera technique. However, there would usually be room for the researcher to empathically manage their reaction to this dissonance in order to protect participant self-perception or image. It may be very difficult to reverse ill-effects associated with situations where a participant has seen themselves engage in “bad” behaviour such as consuming a family pack of potato chips or chocolate bars during a six hour TV viewing session. Furthermore, in traditional techniques, the participant would choose what to reveal, perhaps waiting until a level of trust had been developed. Again, wearable camera images may not allow this. We suggest such an experience could have short term negative outcomes for the participant beyond traditional reported diaries or interviews. This may breach the researchers’ responsibility to avoid harm as directed by principle of non-maleficence. Whether this harm would ultimately be outweighed by the benefits of the intervention is a utilitarian position but certainly unlikely in all cases; we are yet to find a health intervention that works for all people in all situations. The effects, whether positive, negative or neutral are likely to differ from person to person.

Furthermore there is the possibility of participants associating family members or close friends with certain unhealthy behaviours such as: social drinking, large meals, smoking or long sedentary time. There of course may well be associations or relations between these third parties and certain behaviours. However, the participant could jump to these conclusions which may prove unfounded or blame or socially label these other people for the behaviour, which could have long term negative effects for all involved.

Some image based interventions may encourage participants to engage with their images in their own time, on their own devices and perhaps on social web sites. For example there are sites available for sharing jogging behaviour, and some patient groups now use online discussion boards. However, participants may not appreciate the long term implications of publically sharing personal health behaviour information. Embarrassing photos or revelations will be “external and eternal” if shared. This should be explained thoroughly to participants.

There is also the potential for misuse of inappropriate images in such situations. While with modern smartphones participants could arguably do this already, it is important that researchers do not facilitate such behaviour. A “contract of care” should be entered into by both researcher and participant at the start of the intervention clearly stating the responsibilities and acceptable behaviour for both parties.

CAN IMAGE BASED INTERVENTIONS BE CONSIDERED ETHICAL?

There is little literature on the use of ethical interventions based on wearable cameras. More broadly, in 2011 the UK Parliamentary Committee on health behaviour interventions cited intrusiveness and transparency as important factors¹. Image based interventions can be intrusive; they collect vast amounts of data on the wearer’s daily life, their home, habits and health behaviours. They also collect images of other people. Therefore the potential harms of these intrusions should be considered.

The transparency is differential. In the interventions proposed the participant knows they are wearing a camera, and the informed consent should explain the potential risks. However, they will meet and record many third parties who will not have the same level of transparency. However, the intervention is not about them, and we discuss levels of informed consent and permissions for spouse, co-habitants, friends, colleagues and strangers in our previous guidelines[16].

Briefly, this discussion considers who the third party may be, how often they may be photographed, what context they may be photographed in, and the practicality of obtaining consent or permission. For example, family members are likely to be recorded in their own home engaging in behaviours including eating, TV watching and possibly changing clothes if the participant forgets to operate the privacy button. We therefore recommend verbal consent prior to starting data collection. Conversely a member of the public may be recorded on a single image while walking down the street, or perhaps in a shop. In this instance we recommend permission only if the third party enquires about the device. Somewhere in the middle are work colleagues, and we recommend prior permission from line managers and close colleagues, with verbal permission on first meeting with more distant colleagues. We also ask the participant to consider the nature of their work (e.g. in a hospital or school) and interaction with the public.

Perhaps the exception when considering behaviour change is when the third parties are associated with certain health behaviours. This is most likely to include the third parties who we recommend seeking permission either in advance, or on first contact (family members, colleagues, friends and

¹<http://www.publications.parliament.uk/pa/ld201012/ldselect/ldsctech/179/17905.htm>

acquaintances). Researchers may therefore want to recommend that participants explicitly inform these people about the camera, its purpose, their potential link to the behaviour, and how the participant will be using the images (e.g. reflection, interview or sharing on social media). However, this may also induce greater reactivity, becoming an intervention in itself and we therefore m.

LEARNING FROM THE ETHICS OF SCREENING

The ethics of health-screening are well developed. We see certain parallels to behavioural interventions that wish to reveal and then change one or more health behaviours. In their landmark paper of 1968 Wilson and Jungner list ten principles for screening and detection[38]. These cover whether the disease is an important health problem, whether the disease is understood, symptomatic, detectable (with a widely available, acceptable test) and treatable. They also discuss cost-benefit and defining testing and treatment populations[38]. These were updated in 2008 by the World Health Organisation[1] and remain broadly the same. However, the updated version included reference to education, equity, and benefits outweighing harm.

APPLICATIONS FOR WEARABLE CAMERA BASED INTERVENTIONS

While there is a wider discussion on the links to ethics of health behaviour interventions in general, we have selected certain aspects from the ethics of screening we consider relevant to wearable camera interventions.

According to the principles of screening, the costs and resources of such interventions may make access inequitable. This needs careful consideration in intervention design and planning. There is also the question of whether recording thousands of photographs at home and work is acceptable to the population.

An important change in the updated screening guidelines was that “accepted treatment” was replaced by “evidence of effectiveness”[1,38]. This suggests recognition that awareness of disease state can be beneficial, even if there is no known treatment. For example, this was the case with early HIV screening programmes where sexual practices and breast feeding habits could be modified; even though treatments had not been developed, disease state awareness was beneficial.

We see an important parallel here to awareness of unhealthy lifestyle behaviours. We do not know how to change all behaviours for all people (or even some for a few). Therefore, there is the risk of telling people they have poor health, but then saying we don’t know how to change it. They may get the harm to motivation of self confidence of having the negative or risky behaviour revealed as discussed above, but never get the benefit of improving it.

However, it may be that revealing the behaviour with the objectivity of images is an intervention in itself, at least for some people. The awareness of behaviour may be enough to stimulate change for some people. This should be

carefully assessed, monitored and explored in early camera based intervention.

THE BENEFITS

This discussion on ethics has largely focused on the potential harms to participants and others. However, the potential benefits of such interventions are equally part of the discussion. If substantial and significant improvements in health behaviours can be demonstrated, with acceptable low levels of intrusion and burden, these methods should be made available to those who need them most.

A particular consideration comes from the recent move in health promotion from a “risk reduction” approach to one of education and empowerment; these are considered more ethical approaches that do not seek to blame individuals[6]. There are clear opportunities with image based approaches to make them tailored, meaningful, participatory and educational rather than being focused on acting on the participant.

OTHER CONSIDERATIONS

The ethical implications and issues of camera based interventions should also be considered in relation to children and vulnerable groups, where informed consent is more problematic[16].

Further, we have primarily discussed interventions involving persons with one or more unhealthy behaviour. There have also been proposals to use such techniques to monitor and improve performance of medical, nursing or care workers, or to explore patient experience of care and treatment. These carry important considerations of other patients or changing the nature of the care given.

DISCUSSION AND CONCLUSION

STRENGTHS & LIMITATIONS

We feel the strengths of interventions based on images from wearable cameras are the objective and personalised data generated. It remains to be tested if these data are more powerful agents of behaviour change than qualitative self-reported data, and general population level guidelines.

The health behaviour change models we used may be unsuitable frameworks to guide the use of technologies as current theories do not consider both intra-individual and inter-individual differences[13] (for example, individual changes in behaviour depending on time and mood). Thus, there may be a need to reevaluate behaviour change theories to exploit engaging and motivating technologies.

Current technology may not yet be sufficiently mature for deployment in a widespread lifestyle health behaviour change intervention. For example the accuracy of automatically classifying data episodes into behaviour type and context information may currently be unsatisfactory for an acceptable user experience[9,34]. Future developments should be shared in an open-source manner[12] to enable the activity recognition community proceed more quickly.

RECOMMENDATIONS

We believe the use of first person images may help elicit health behaviour change. This is due to the potential of these images to support known behaviour change strategies identified in Table 1, namely: awareness, fun & enjoyment, motivation, confidence, and reviewing progress. It is time to test these ideas, in conjunction with and versus traditional strategies in order to assess their effectiveness.

It is also important that such work considers the ethical implications of this research and adheres to accepted guidelines and principles. We make the following ethical recommendations:

- Follow the existing framework for ethical research with wearable cameras during data collection[16]
- Include the additional aspects discussed here in participant information prior to collection of informed consent
- Enter into a “contract of care” detailing roles and acceptable behaviour for both researcher and participant. This should include the taking and sharing of images.

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