Combining persuasive technology and behaviour change techniques to support health behaviour change in people with COPD

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1 Table of Contents

1.1 Abbreviations

6MWT/D – 6 Minute Walk Test/Distance
ADL- Activities of Daily Living
BCI – Behaviour Change Interventions
BCT – Behaviour Change Technique
BLF – British Lung Foundation
CA – Continuous Abstinence (measure of smoking cessation)
CHAMPS – Community Health Activity Model programme for Seniors
COPD – Chronic Obstructive Pulmonary Disease
DoH – Department of Health
ESRES- Exercise Self-Regulation Self-Efficacy Scale
FBM – Fogg Behavior Model
HCP – Health Care Professional
HRQoL- Health related Quality of Life
MM – Music and Maps
MRC – Medical Research Council
NICE – National Institute of Health and Care Excellence
NRT – Nicotine Replacement Therapy
OC – Online Community
PA – Physical Activity
PDA – Personal Digital Assistant
PP – Point Prevalence (measure of smoking cessation)
PP – Perceived Persuasiveness
PR – Pulmonary Rehabilitation
PTT – Persuasive Technology Technique
PSD – Persuasive System Design
PwCOPD – People with COPD
QoL – Quality of Life
RCT – Randomised Controlled Trial
SC – Smoking Cessation
SMART-Self Management supported by Assistive, Rehabilitation and Telecare Technologies
SSM – Stop Smoking Medication
SSS – Stop Smoking Services
SUS- System Usability Scale
TAM- Technology Acceptance Model
TRA – Theory of Reasoned Action
VC – Virtual Coach
WoK – Web of Knowledge

1.2 *Abstract*

Background: Persuasive technology is a term used to describe 'any interactive computing system designed to change people's attitudes or behaviours' (Fogg, 2003, p.1). This thesis seeks to explore how persuasive technology could be combined with behaviour change techniques (BCTs) and used to help people with chronic obstructive pulmonary disease (PwCOPD) to make changes to their health behaviours.

Methods: Two systematic reviews with meta-analyses were conducted to identify BCTs associated with effective interventions in this population (Study 1 and 2). A series of mixed-methods, *N*-of-1 studies were used to assess an existing persuasive technology (a mobile phone app) with PwCOPD (Study 3). And finally, interviews and surveys were used to collect the opinions of key stakeholders towards the use of persuasive technology to increase physical activity in PwCOPD (Study 4).

Results: Study 1 identified that self-regulatory BCTs were effective in smoking cessation interventions for PwCOPD. Study 2 identified that intervention components that targeted physical activity delivered as part of a multi-faceted intervention were most effective. Study 3 showed that the mobile phone app was used daily, five of the seven participants increased their mean daily step count, although greater support would be needed to set independent physical activity goals. Study 4 found that there was support for persuasive technology to take a more active role to encourage physical activity. However, incorporating aspects such as competition divided opinion.

Discussion: The findings reported illustrate the potential of combining persuasive technology with BCTs to support behaviour changes in PwCOPD. This approach was largely found to be acceptable and strategies to increase both the acceptance, and the utility, of this approach are suggested. Future research should continue to explore how best to use BCTs in conjunction with persuasive technology to support and encourage PwCOPD to makes changes to their health behaviours.

1 Introduction

> *'Seventeen and a half million people in this country report living with a long-term condition. Of these, many live with a condition that limits their ability to cope with day-to-day activities.' David Colin-Thomé, National Clinical Director of Primary Care (Department of Health, 2005, p.3)*

This thesis investigates the potential of persuasive technology to encourage effective self-management of chronic obstructive pulmonary disease (COPD). COPD is an umbrella term used to describe chronic bronchitis, chronic emphysema and a number of other obstructive pulmonary conditions. COPD is a long-term, or chronic, condition that requires ongoing care, and as such is costly to the National Health Service (NHS). If people with COPD (PwCOPD) can be supported to effectively self-manage their condition through making changes to their lifestyle, such as stopping smoking and increasing physical activity, this has the potential to improve their lives (Bourbeau, Nault, & Dang-Tan, 2004). In doing so it could also potentially relieve some of the burden that COPD places on the health service (Christenhusz, Prenger, Pieterse, Seydel, & van der Palen, 2012).

Supporting and encouraging behaviour change can be approached through the development and implementation of behaviour change interventions (BCIs), defined as 'coordinated sets of activities designed to change specified behaviour patterns' (Michie, van Stralen, et al., 2011, p.2). Researchers have begun to investigate the unique capabilities that technology may have to support individuals to change their behaviour. If technology is used in this way it can be referred to as *persuasive technology* (Fogg, 2003). Although there are many examples of persuasive technology that have been designed to change behaviours related to health, the majority of this technology does not use evidence based theories and techniques from the field of health psychology (Abroms, Padmanabhan, Thaweethai, & Phillips, 2011; Rabin & Bock, 2011; Rosser & Eccleston, 2011). This thesis therefore explores the potential of combining evidence based theories and techniques from health psychology, with the unique capabilities that persuasive technology may have to encourage behaviour change, in the context of COPD self-management.

This introductory chapter provides the background for this project, the overall methodological approach taken, and concludes with the aims and objectives of the thesis. This chapter provides an overview of the field as it was when the project was started, and the landscape that the project's aims and objectives fit within. Over the years advances have been made in the fields related to this project; these, and how the findings of the project can be conceptualised within them, are provided in the general discussion chapter (Chapter 8).

1.1 Background

To place the aims and objectives of this research in context, the use of technology, and health psychology, in the development of BCIs will be explored. This will be followed by a brief overview of COPD and the current treatment approaches, and a background review of how technology has been used with this population.

1.1.1 The use of technology in BCIs

The use of technology in BCIs has been steadily growing for decades (Barak, Klein, & Proudfoot, 2009; Chatterjee & Price, 2009; Danaher & Seeley, 2009; Ritterband & Tate, 2009). Technology can be available 24 hours a day and provided to large numbers of people at low cost (following development) making it an attractive and cost-effective option for researchers who develop BCIs (Ritterband, Thorndike, Cox, Kovatchev, & Gonder-Frederick, 2009). In a review of internet-based BCIs (where participants included both the general public and those with long-term conditions), results were found to be equivalent to more traditional face-to-face interventions for many of the behaviour changes targeted, with positive effects on both symptoms and quality of life (Ritterband & Tate, 2009).

The potential utility of technology to bring about changes in behaviour can be seen by the vast numbers of websites and mobile phone apps that are available for the general public. The iPhone app store, Android marketplace and Windows app marketplace all feature 'health and fitness' categories and, in October 2011, over 21,000 applications were listed in this category of the iPhone store alone (although many of these applications would be duplicated on the other sites). Many of these apps encourage and support people with changes to their behaviour including dieting, increasing physical activity, improving sleep behaviour and smoking cessation. There is concern however that many apps are not based on appropriate behaviour change theories (Abroms et al., 2011; Rabin & Bock, 2011; Rosser & Eccleston, 2011).

Initially, technology was seen as a low cost way to increase the availability of, and access to, more traditional 'pen and paper' or face-to-face BCIs, and was defined and understood through the same theories and approaches as the original BCIs (Proudfoot et al., 2011). However, as technological capabilities have increased, a greater level of interaction and tailoring has become possible (Chatterjee & Price, 2009). Mobile phones and bodily sensors mean technology has the ability to always be with someone, this offers new opportunities for changing behaviours (Andrew, Borriello, & Fogarty, 2007; Chatterjee & Price, 2009), so that now technology that supports healthcare 'integrate(s)…more seamlessly into everyday life, regardless of space and time' (O'Grady, O'Hare, & O'Donoghue, 2011, p.27).

A well-known example of this type of technology is the Nike+® system that aims to encourage and increase physical activity. The system consists of an app that uses both the accelerometer and global positioning system (GPS) that is built into many smartphones, together with optional additions such as trainers, wristbands and watches with additional monitors. When the user goes for a run, they can either track their route using the app, or use one of the other sensors. The data collected, perhaps related to speed, distance and location, is automatically uploaded so that the user can review it using their phone, tablet, or computer. As the user may have their phone, wristband or watch with them while they are running, this allows for additional motivation during the activity itself, such as displaying how much further they would have to run to reach their target, or showing how this run compares with their personal best. This is just a basic overview of a system; additional features include the ability to access training plans and share the distance and speed achieved on social media sites.

The flexibility afforded by using technology gives users the ability to design a bespoke BCI for themselves. Nike+® is just one example of this type of system that is available for the general public. In comparison with a paper based training plan that the user would need to fill in when they returned from their run, the use of technology such as smart phones and sensors allows for; contact with the BCI at the most appropriate time (i.e. during the run itself); the ability to receive real-time, objective feedback about progress; and to connect with others. All these capabilities have the potential to increase the persuasiveness of technology (Fogg, 2003), and therefore the effectiveness of a BCI that uses them. These opportunities would be missed by a direct translation of a traditional BCI into a BCI delivered using technology; for example, by making a paper-based training plan available on a website. Where technology may previously have been seen as a poor alternative to, for example, face-to-face contact, the unique capabilities of technology to change behaviour are now being explored (Wai & Mortensen, 2007).

Several reviews of internet delivered BCIs have acknowledged that there are additional factors, unique to delivery through technology, which might influence the effectiveness of BCIs. As well as looking at the active components of BCIs or 'behaviour change techniques' (BCTs) and the theoretical basis of the interventions drawn from health psychology, factors such as level of automation (Rosser, Vowles, Keogh, Eccleston, & Mountain, 2009; Shahab & McEwen, 2009;

Webb, Joseph, Yardley, & Michie, 2010), mode of delivery (Laplante & Peng, 2011; Rosser et al., 2009; Shahab & McEwen, 2009; Webb et al., 2010) and level of tailoring (Shahab & McEwen, 2009) have also been identified as important. The translation of more traditional forms of therapy and BCIs to a technological form of delivery therefore, requires careful thought and planning (Rosser et al., 2011).

Great advances have been made in making computers easier and more enjoyable to use (Sharp, Rogers, & Preece, 2007). With these increased capabilities, the importance of 'user experience' (UX) has grown. Now software designers are not only concerned with how easy something is to use (usability) but also how enjoyable it is to use (Hassenzahl & Tractinsky, 2006). Technology-based BCIs often report poor adherence rates, limiting their effectiveness. Designing the technology to be more persuasive may help to address this (Kelders, Kok, Ossebaard, & Van Gemert-Pijnen, 2012).

1.1.2 Persuasive Technology

Persuasive technology is defined as 'any interactive computing system designed to change people's attitudes or behaviours' (Fogg, 2003, p.1). This emerging field of research focuses on the capabilities that are unique to technology that might persuade users to perform certain behaviours (Fogg, 2003; Sharp et al., 2007), and moves beyond making behaviours that the user wants to perform easier (although this is an important aspect of persuasive technology) and focuses instead on encouraging users to think and act differently (Fogg, 2003). This idea is gaining support in the area of health behaviour change. In a 2011 framework for eHealth designers, it was stated that, 'via persuasive techniques, eHealth technologies can be designed to match user profiles, and to motivate or inspire patients to engage in self-management' (van Gemert-Pijnen et al., 2011, e127).

The field of persuasive technology was largely defined with the publication of 'Persuasive technology: Using computers to change what we think and do' (Fogg, 2003). Here it was suggested that technology can play three different roles[1], or functions, in persuading people, referred to by Fogg as the 'functional triad' (Fogg, 2003, p.23). Technology can act as a *tool*, making it easier to perform a target behaviour; this could be by performing calculations, or guiding the user through a process. Technology can act as a *social actor*, creating a relationship

[1] In Fogg's work the concept of the functional triad is described as related to Computers As Persuasive Technology or *captology*, with computers at the centre (Fogg, 2003). However with the increasing technological convergence between computers and other devices such as mobile phones, and televisions the term persuasive technology will be used in this thesis as it gives a more complete view of the area.

between the user and the persuasive technology that allows rewards, feedback, reciprocity and social support in a similar way to a face-to-face relationship. Finally, technology can act as a *medium*, allowing the user to experience something different through the technology, either before trying it in real life (termed *rehearsal*) or before deciding on a plan of action (termed *simulation*) (Fogg, 2003). Fogg's conceptualisation of the different roles that technology could play elevates technology from a mode of delivery, to something that is capable of playing an integral part in the BCI.

To clarify, the way that Fogg (2003) describes persuasive technology implies that the technology is seen as its own entity, with its own persuasive techniques. This is in comparison to computer-mediated communication which includes approaches such as therapists communicating with clients online, for example through online therapy, online counselling and online support groups (see Barak et al., 2009 for further description of these categories). The difference is that persuasive technologies have been specifically designed with this purpose, rather than used as a channel for people to persuade, one person to another (Fogg, 2003). It has been argued, however, that all of these approaches should be defined as computer-mediated communication (Atkinson, 2006) as it is not the technology that is doing the persuading, but the designer of the technology. While it is clear that computers and technology can only do what they have been programmed to do, the view taken in this thesis is that of Sharp and colleagues (Sharp et al., 2007) that to the user, the designer is somewhat invisible. This means that, when a computer program rewards a user for a correct response, from the user's perspective it would be an interaction with the technology, not the designer. For simplicity, and to differentiate between persuasive technology as defined above and systems designed to allow communication between people, the remainder of this thesis makes reference to technology persuading and user's interactions with technology in the way that Fogg has described it (Fogg, 2003). Although it is acknowledged that a more precise description would be that the technology has been used as a 'vehicle of persuasion' (Torning & Oinas-Kukkonen, 2009, p.1).

It is important at this stage to introduce the ethics of persuasive technology, and define exactly what is meant by 'persuasion'. The term 'persuasion' has historically proved difficult to define (Fogg, 2003; O'Keefe, 2002). O'Keefe suggests:

> *'[an] intentional effort at influencing another's mental state through communication in a circumstance in which the persuadee has some measure of freedom' (O'Keefe, 2002, p.5)*

O'Keefe acknowledges, however, that there are many variables included in this definition which blur the distinction between what is counted as persuasion and what isn't. For example, the level of freedom and the type of communication (2002). In the case of persuasive technology, the communication is delivered by some electronic means, but the core components of intentionality and free choice of the persuadee are key (Fogg, 2003). Without intentionality and free will, persuasive technology could be considered coercive.

1.1.3 Models related to Persuasive Technology

Although it is only a decade since the field of persuasive technology was defined, how people act in relation to technology has been studied by software designers and human computer interaction specialists for decades. While the definitions and models developed in these areas do not specifically mention persuasive technology, they provide insights related to how and why people choose to use technology. For persuasive technology to be successful in changing behaviours related to health, it needs to encourage both initial and continued use of the technology by engaging the user (Davies et al., 2012). Only following successful engagement with the technology, can behaviours unrelated to the technology use, such as increasing physical activity, be targeted (Davies et al., 2012; Or & Karsh, 2009)

Technology use and acceptance

Various theories describe the process by which people either accept or reject new technologies and the factors that might contribute. One of the most often cited is Rogers' Diffusion of Innovations Theory (Rogers, 2003). This comprehensive theory describes three aspects related to adopting a new technology: i) The characteristics of people who adopt technology at different rates (i.e. early, as opposed to late adopters); ii) the routes of communication used for diffusion through a community, or workplace; and iii) the process that each individual goes through to begin using the new technology. Rogers then splits this decision into 5 stages; (i) knowledge, when the person has heard of the technology, but doesn't know enough about it; (ii) persuasion, when someone actively seeks out information about the technology; (iii) decision, when the person calculates the benefits compared to the losses in using the new technology and decides whether they will use it; (iv) implementation, when the person begins to use the technology and assesses the usefulness to them; and finally, (v) confirmation, when the person decides to either use the technology routinely, or reject it (Rogers, 2003).

The Technology Acceptance Model (TAM; Davis, Bagozzi, & Warshaw, 1989) focuses on the determinants of an individual's intention to use, and then acceptance of, a new technology and is another widely used model in this area. The TAM focuses on the decision and implementation stages of the Diffusion of Innovation Theory (Rogers, 2003) and describes the factors that contribute to people forming an intention to use a technology. To achieve this, the TAM adapts the theory of reasoned action (TRA; Fishbein & Ajzen, 1975) which is a general model of behaviour that was designed to apply to any behaviour the person has control over. The TRA identifies two factors that influence the intention to perform a behaviour; an individual's attitude towards that behaviour and subjective norms. Attitudes reflect beliefs and evaluations of the behaviour. In turn, subjective norms reflect an individual's perceptions of what other people would think of them performing the behaviour, together with how motivated they are to act in accordance with what others think.

The TAM adapted the TRA to include variables that specifically predict technology use. In 1989, the authors of the TAM postulated that perceived ease of use and perceived usefulness combined to influence a person's attitude towards the technology, this attitude then predicts the intention to use the technology, and subsequent use (see Figure 1.1). The model recognises that external factors might influence perceived ease of use and perceived usefulness, and that how easy a technology was to use might influence how useful someone perceived it to be.

The TAM is one of the most widely used models in technology acceptance and has been found to be 'robust and valid' in a variety of settings (King & He, 2006, p. 740). It should be noted that this refers to the industry settings for which the model was designed (e.g. introducing new technology to an office). In 2010, Holden and Karsh reviewed 16 publications that had explored the use of TAM in healthcare and found support for the model, especially the role of perceived usefulness which was found to be a significant predictor of intention in all the papers reviewed. However, this review only included healthcare professionals as the end users, not patients (Holden & Karsh, 2010).

Although undoubtedly parsimonious (Holden & Karsh, 2010), elements such as subjective norms in the TRA are not accounted for in the TAM. Over the years, different variables and relationships have been added to the original TAM to form TAM2 and TAM3. In 2003, Venkatesh and colleagues conducted a comprehensive review of available theories of technology use and acceptance (including various iterations of the TAM) and combined those elements that had the most empirical support into the Unified Theory of Acceptance and Use of Technology (UTAUT, see Figure 1.2; Venkatesh, Morris, Davis, & Davis, 2003). The key concepts of the TAM, perceived ease of use and perceived usefulness, were present but renamed as effort expectancy and performance expectancy. Additionally, the UTAUT contained social influence and facilitating conditions as predictors of intention.

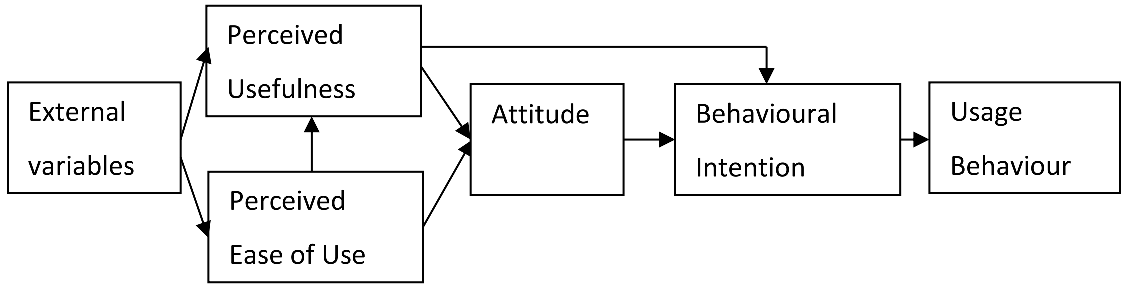

Figure 1.1: Technology Acceptance Model. Reprinted by permission, Davis et al. User acceptance of computer technology: A comparison of two theoretical models Management Science, 35(8), August , 1989. Copyright (1989), the Institute for Operations Research and the Management Sciences, 5521 Research Park Drive, Suite 200, Catonsville, Maryland 21228 USA

The UTAUT has been described as a 'substantial improvement' on the TAM (Or et al., 2011, p.53) and has been found to predict 69% of the variance in acceptance of technology (Venkatesh et al., 2003). Both the TAM and the UTAUT have been used to assess the acceptance of technology across a wide range of situations including health care professionals use of new technology (Holden & Karsh, 2010), and the use of electronic health records by both professionals and patients (Wilson & Lankton, 2004). In addition, the UTAUT has been used to predict the acceptance of a self-management website by people with chronic heart-failure (Or et al., 2011). Models in this area are constantly evolving to incorporate new technology, new populations, new determinants of acceptance, and the new situations technology is being used in. For example, the Senior Technology Acceptance and Adoption Model (STAM) which proposes older adults may pass through different stages in accepting technology than younger adults (Renaud & van Biljon, 2008), and the Mobile Health Technology Acceptance Model (MoHTAM) which is currently relatively untested, but suggests the role of both socio-cultural factors and technology factors can influence the perceived usefulness and perceived ease of use of m-Health technology (Mohamed, Tawfik, Al-Jumeily, & Norton, 2011).

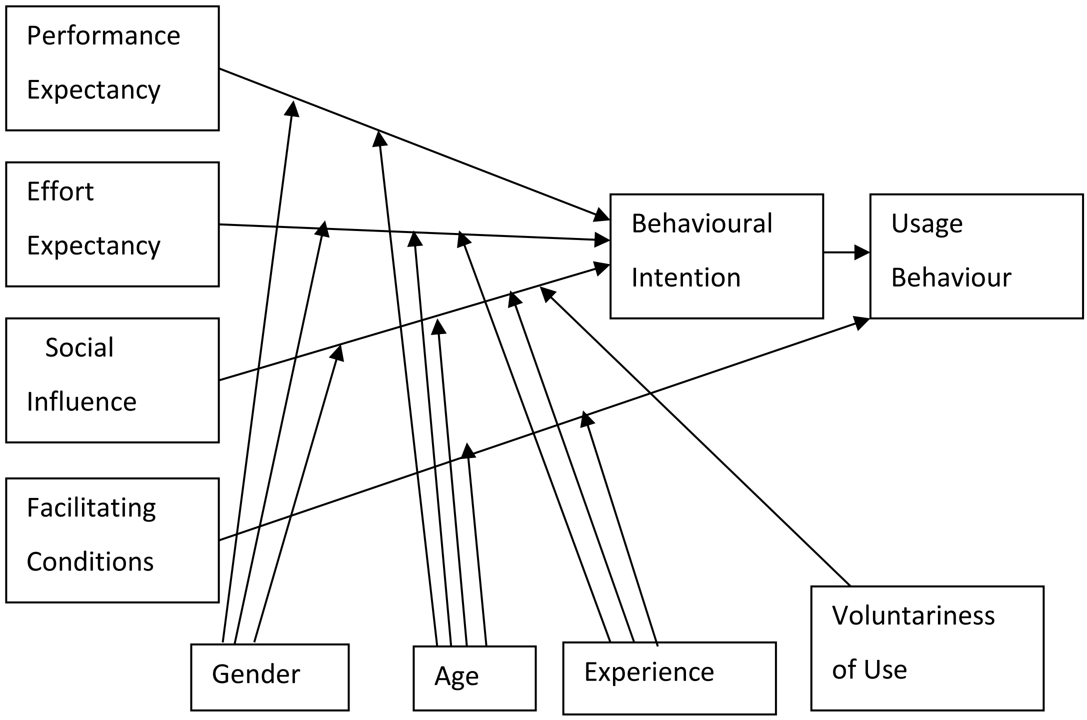

Figure 1.2: Figure 2 Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003)

Advances have undoubtedly been made in understanding the determinants of technology acceptance and use. However, as the TAM was heavily influenced by the TRA and the UTAUT, STAM and the MoHTAM are extensions of the TAM, some of the criticisms that have been levelled at the TRA, also apply to these technology acceptance and use models. Two of the main criticisms of the TRA are that i) it is not clear how those developing BCI should incorporate the components of the model (Hardeman et al., 2002) and ii) the formation of an intention does not necessarily lead to action (Sheeran, 2005; Webb & Sheeran, 2006). The first of these problems will be addressed below with the introduction of models that explore how developers of BCIs can make technology more persuasive. The latter will be explored in Section 1.1.4.

The Internet Intervention Model

In 2011 guidelines were published to guide the growing field of internet interventions (Proudfoot et al., 2011). These guidelines noted that, thus far, the *process variables* (or the mechanisms which describe how the intervention actually elicits its effect) have been derived from existing theories of behaviour change and other forms of BCI. As described in Section 1.1.1, this approach is unlikely to make full use of the opportunities provided by technology. The exception given to this was the 'Internet Intervention Model' (see Figure 1.3; Ritterband et al., 2009). Beginning with the factors that influence website use (characteristics of the website itself; level of support; environment and user characteristics), if the user does use the website, the next variable of importance is the *mechanism of change*. This refers to the way in which the website aims to change the target behaviour. Following use, and exposure to the mechanisms of change, an individual's behaviour is thought to change resulting in symptom improvement and ideally treatment maintenance. The environment the intervention is being accessed in is thought to have an effect on every stage of the process (including the user characteristics, Ritterband et al., 2009).

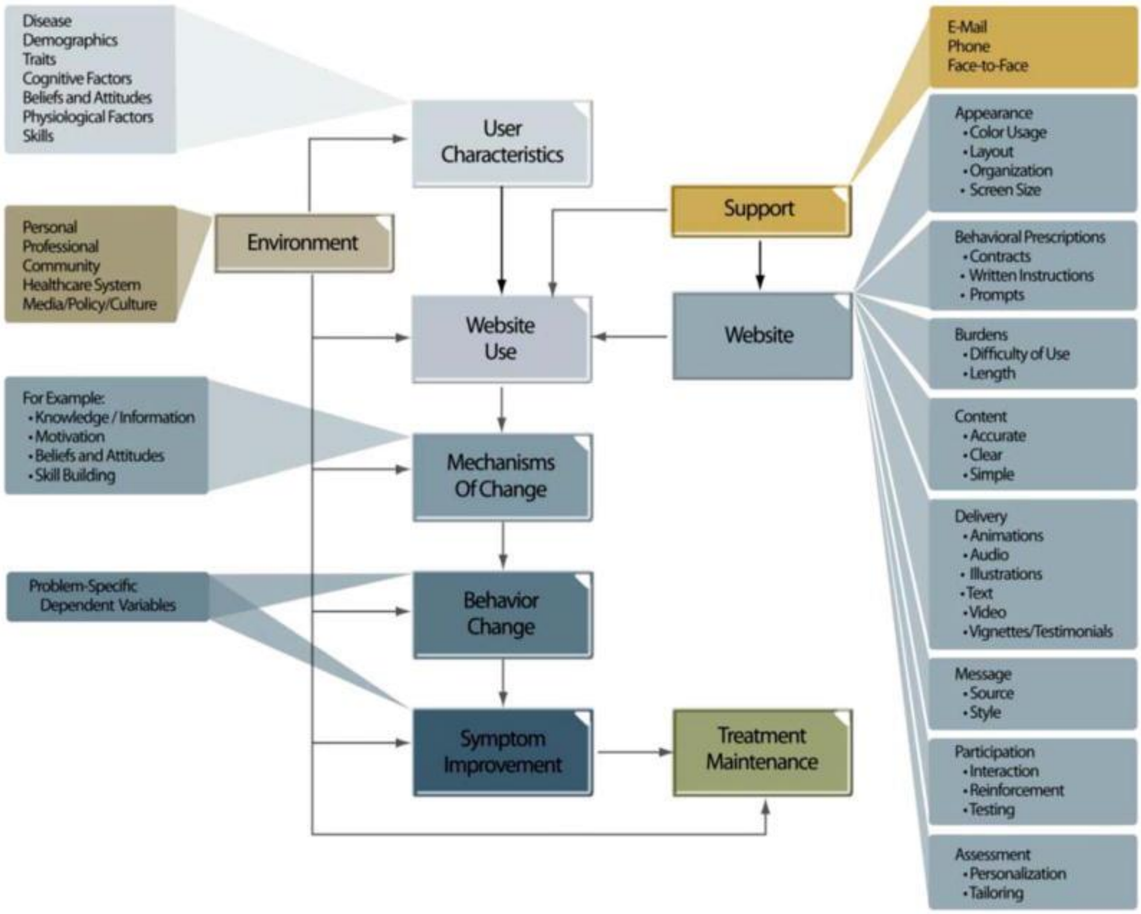

Figure 1.3: The Model of Internet Interventions reproduced with permission from Ritterband et al., 2009 Copyright © Springer

Although presented as a more or less linear path, Ritterband et al., note that this is an over simplification, and the path is iterative; by using the internet intervention the contributory factors of the model can be affected. For example, someone's beliefs and attitudes might affect initial use, but these may be changed when the person uses the internet intervention and finds it enjoyable, or frustrating (Ritterband et al., 2009). This is an interesting model as it covers elements of the theories explored in the above section such as the Technology

Acceptance Model (Davis et al., 1989) and the Diffusion of Innovations theory (Rogers, 2003), as well as theories exploring the psychological components of behaviour change. In addition, Ritterband and colleagues' model provides a practical framework for designing BCIs using technology. Although there is no specific mention of persuasive technology, some of the areas covered by the *website* component are obviously designed to increase user's enjoyment and motivation to continue to use the intervention, and change the behaviour (Ritterband et al., 2009). What Ritterband et al., describe as website components, could also be described as persuasive technology techniques, as they make use of the unique capabilities of the technology to affect attitude and/or behaviour. For example, a website that uses prompts to encourage *interaction* with it may be more persuasive than a website that is more static; the use of techniques such as *personalisation* and *tailoring* aim to make the intervention more personally relevant to the user, which is a commonly used technique in persuasive communication (Petty & Cacioppo, 1986).

The Internet Intervention Model classifies the *mechanisms of change* as separate from the characteristics of the website (Ritterband et al., 2009). The characteristics lead to use and then, through using the website, the mechanisms of change can bring about a change in behaviour. In a sense, the approach taken relegates the persuasive features of the website to persuading the user to use the website, not as having a role in the behaviour change itself. While persuading the user to use the technology or website initially is essential as a first step (Davies et al., 2012), following this, the novel approach that persuasive technology takes is that aspects of the website or technology design can also motivate and facilitate behaviour change (Fogg, 2003). Incorporating elements that aim to persuade promotes technology from a means of delivering the intervention, to being integral to the intervention itself. Nevertheless, the Internet Intervention Model (Ritterband et al., 2009) is a step towards integrating the unique aspects of technology with the more psychological concepts that might underpin a successful BCI. Human communication interaction models such as The Internet Intervention Model, the TAM and the UTAUT could all be described as taking a 'top down' approach, beginning with an understanding of behaviour and using this to design intervention components delivered via technology. In contrast, recent research that specifically focusses on persuasive technology has used a 'bottom-up' approach, beginning with identifying the aspects of an intervention that appear to be effective, and working towards a theory of behaviour that might explain them.

The Fogg Behaviour Model

Fogg and colleagues at Stanford University have used a bottom-up, data-driven approach to develop their understanding of behaviour change. This includes a three component model of behaviour change (Fogg, 2009a) and a behaviour change grid that describes the types of behaviours that can be targeted with persuasive technology (Fogg, 2009b). The 'Fogg Behaviour Model' (FBM) proposes that, in order for someone to change their behaviour, they must be motivated, capable, and an appropriate trigger must occur (appropriate being a trigger that occurs at the right time, or in the right format; Fogg, 2009a). The types of behaviour that the FBM applies to have been defined in a 'Behaviour Change Grid' (Fogg, 2009b). The grid identifies 35 categories of behaviour change. Five types of behaviour change form the columns of the grid: i) Perform a new behaviour; ii) perform an existing behaviour; iii) increase a behaviour; iv) decrease a behaviour; or, v) stop a behaviour. Seven different schedules form the rows: i) Perform a behaviour just once; ii) repeat the behaviour leading to an ongoing obligation; iii) sustain the behaviour for a period of time; iv) repeat the behaviour according to a fixed schedule; v) repeat the behaviour according to a cue; vi) repeat the behaviour whenever the user wants; or vii) repeat the behaviour every time a task is performed. The cells of the grid then make up the 35 categories of behaviour change. For example if someone wanted to eat smaller portions at dinnertime, Fogg et al., would describe this as a decrease in a behaviour, repeated according to a fixed schedule. It is asserted that by manipulating the three factors specified by the FBM (motivation, ability and triggers) all 35 categories of behaviour change can be achieved through a persuasive technology BCI (Fogg, 2009b).

The FBM has been developed largely independently of extant research in the field of health psychology. Models and theories of behaviour change are listed in a 'related research' page on the website for Stanford Persuasion Labs (http://captology.stanford.edu/) but there is no discussion of how the FBM might relate to these. The conceptual basis of the FBM is not, therefore, previous models of health behaviour change, but a detailed understanding of technology and how it can be used to persuade. This understanding is based on observation and experimentation with different persuasive technology techniques. While in health psychology the BCI design would traditionally follow the theory, in the case of the FBM it seems that the theory was developed after successful BCIs have been developed. This can be seen in the 8-step process outlined by Fogg to guide BCI developers in designing persuasive technology (see Figure 1.4). The importance of building on previous examples of persuasive technology is outlined in Step 5, but there is no mention of identifying and using theory to inform the development.

The FBM has not been validated in the same way as models of behaviour change from health psychology have, but there are ongoing projects that utilise the FBM to design persuasive technologies (e.g. Ferebee, 2010; Foster, Linehan, Kirman, Lawson, & James, 2010; Moraveji, Akasaka, Pea, & Fogg, 2011; Nijland, Van Gemert-Pijnen, Kelders, Brandenberg, & Seydel, 2011; Young, 2010), which may in the future provide this validation. These projects are mainly at a formative stage and have so far only been reported in conference proceedings rather than journal publications. Therefore, to date, there is limited evidence of whether the FBM leads to actual behaviour change, although there is evidence that the BCIs developed are both acceptable and used by the people that they target (e.g. Young, 2010). As well as ongoing practical testing, there are also theoretical developments based on the FBM, including the production of a heuristic to evaluate persuasive technology (Kientz et al., 2010) and the development of the 'Persuasive Systems Design' model (PSD; Oinas-Kukkonen & Harjumaa, 2009).

The Persuasive Systems Design Model

The PSD model was developed with close reference to Fogg's functional triad approach (that technology can take the role of a tool, a social actor or a medium; Fogg, 2003). However, Fogg's functional triad focused on the actions of the technology, the behaviour of the user is explained by the FBM (Fogg, 2009a), the characteristics of the behaviour change being described in the '35 behaviour grid' (Fogg, 2009b) and the guidance for persuasive technology BCI development was given in the '8-step design process' (Fogg, 2009c). In the PSD, Oinas-Kukkonen & Harjumaa take a more complete look at persuasion using technology, and integrate all of these elements in a single model (Oinas-Kukkonen & Harjumaa, 2009).

The PSD model is linear in nature (see Figure 1.5) and begins with a number of postulates that the designer must understand in order to design a persuasive system. The model then moves on to encourage the designer to provide a detailed description of the persuasion context. The context is broken down into the intent (who is trying to persuade, and the type of change desired); the event (how the technology is going to be used, who it is going to be used by, and why this technology has been chosen) and the strategy of persuasion (direct or indirect) (Oinas-Kukkonen & Harjumaa, 2009). Once the postulates and the persuasive context have been understood, the design of the system follows. According to the PSD model, there are 28 persuasive technology techniques (PTTs) that can be utilised when designing persuasive systems. These are organised into four categories of techniques: i) Techniques that aid in carrying out the target behaviour termed *primary task support*, similar to Fogg's conceptualisation of the computer as a tool; ii) techniques that motivate through feedback termed *dialogue support* - some of these techniques would be defined as tools by Fogg, others as examples of the technology playing the role of a social actor; iii) techniques that make the system appear credible to the user, termed *credibility support*; and finally, iv) techniques that use social support, termed *social support* . For a list of these persuasive technology techniques see Table 1.1.

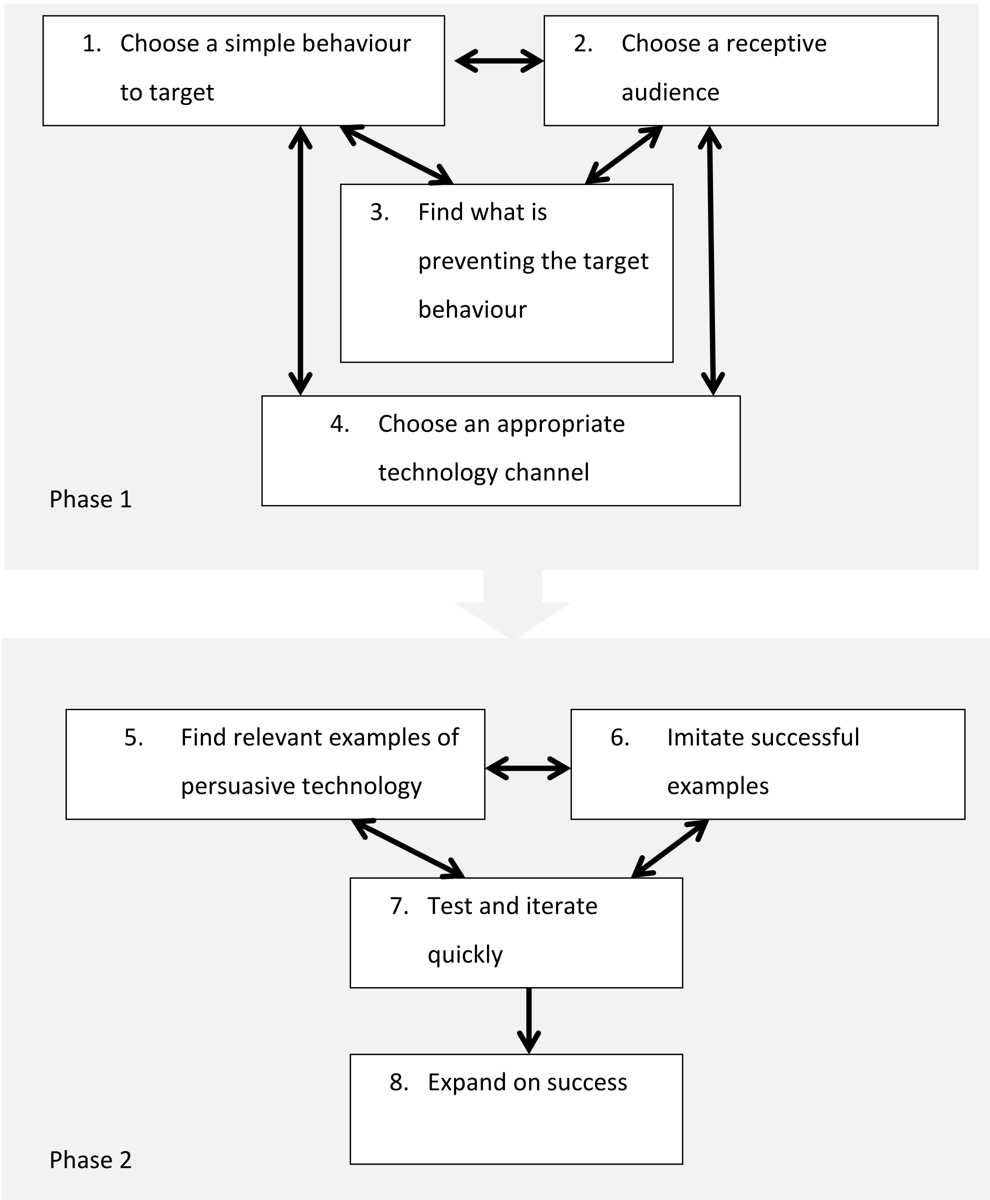

Figure 1.4: 8-step persuasive technology design process (Fogg, 2009c). Reproduced with permission Copyright © 2009 Association for Computing Machinery, Inc

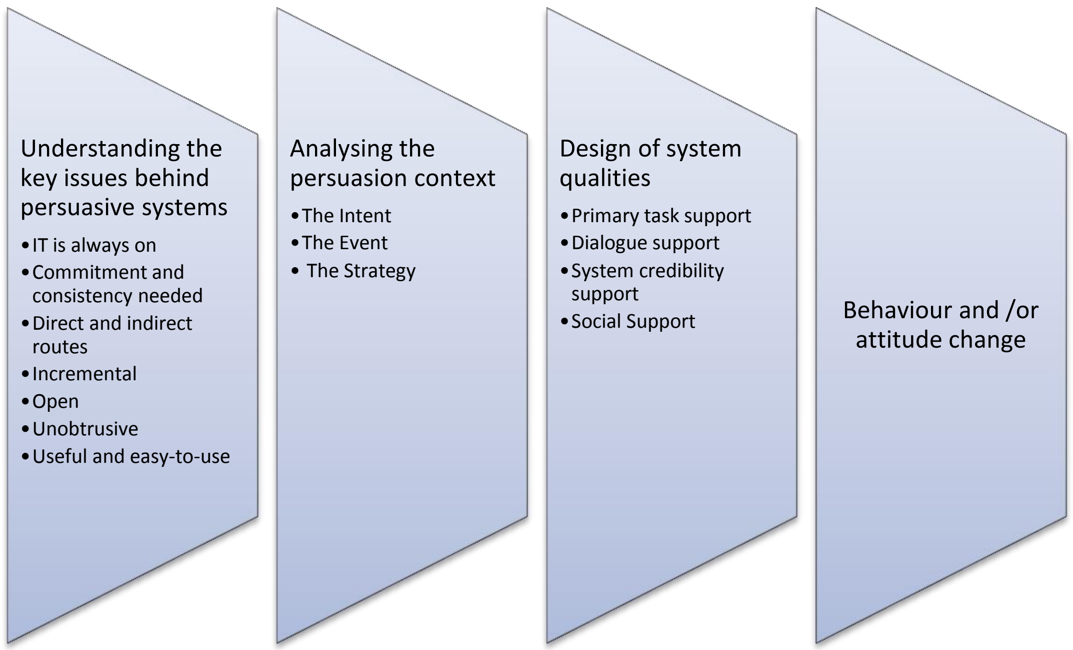

Figure 1.4: Persuasive Systems Design Model, re-drawn with permission from Oinas-Kukkonen & Harjumaa, 2009

The PSD has been described as the most sophisticated model in this area so far (Lehto & Oinas-Kukkonen, 2011). The authors describe it as a useful tool for evaluating existing interventions to identify which persuasive components are most effective, and also for building persuasive interventions in the future. However, the practicalities of applying this model to design interventions are still uncertain (and relatively untested). For example, the PSD does not give any guidance about how to design what are described in the above diagram as the *system qualities*, either in terms of categories of PTTs, or specific PTTs.

In summary, persuasive technology is a relatively novel area of research (at least when compared to research in the field of health psychology), but it is an area that shows promise in the development of BCIs. The use of technology in this context seems to appeal to the general public (as evidenced by the vast numbers of apps available, and the results related to acceptance of these technologies), and some understanding has been gained related to roles that technology can play in a BCI. However, the theories that have been developed to describe the psychological processes that underlie the effect of these technologies on behaviour are relatively untested at present.

Table 1.1: Persuasive technology techniques (PTTs) from Oinas-Kukkonen and Harjumaa (2009), reproduced with permission

Categories	Principles	Delivery as PTTs
Primary task support	Reduction	A system that reduces complex behaviour into simple tasks helps users perform the target behaviour, and it may increase the benefit/cost ratio of a behaviour.
	Tunnelling	Using the system to guide users through a process or experience provides opportunities to persuade along the way.
	Tailoring	Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group.
	Personalisation	A system that offers personalized content or services has a greater capability for persuasion
	Self-monitoring	A system that keeps track of one's own performance or status supports the user in achieving goals.
	Simulation	Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.
	Rehearsal	A system providing means with which to rehearse a behaviour can enable people to change their attitudes or behaviour in the real world.
Dialogue support	Praise	By offering praise, a system can make users more open to persuasion.
	Rewards	Systems that reward target behaviours may have great persuasive powers
	Reminders	If a system reminds users of their target behaviour, the users will more likely achieve their goals.
	Suggestion	Systems offering fitting suggestions will have greater persuasive powers
	Similarity	People are more readily persuaded through systems that remind them of themselves in some meaningful way
	Liking	A system that is visually attractive for its users is likely to be more persuasive.
	Social Role	If a system adopts a social role, users will more likely use it for persuasive purposes.
Credibility support	Trustworthiness	A system that is viewed as trustworthy will have increased powers of persuasion
	Expertise	A system that is viewed as incorporating expertise will have increased powers of persuasion
	Surface credibility	People make initial assessments of the system credibility based on a first-hand inspection.
	Real-world Feel	A system that highlights people or organization behind its content or services will have more

		credibility
	Authority	A system that leverages roles of authority will have enhanced powers of persuasion.
	3rd Party Endorsements	Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility.
	Verifiability	Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.
Social support	Social Learning	A person will be more motivated to perform a target behaviour if (s)he can use a system to observe others performing the behaviour.
	Social Comparison	System users will have a greater motivation to perform the target behaviour if they can compare their performance with the performance of others.
	Normative Influence	A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behaviour
	Social Facilitation	System users are more likely to perform target behaviour if they discern via the system that others are performing the behaviour along with them.
	Cooperation	A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to co-operate
	Competition	A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to compete
	Recognition	By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behaviour.

1.1.4 Health psychology approaches to BCI development

The field of health psychology has many well-tested theories of the psychological factors that underpin behaviour change and therefore could provide an empirical basis for the design of BCIs using persuasive technology. The TRA, a psychological theory of behaviour change has already been introduced as the basis for the TAM and the subsequent UTAUT. As outlined above, these theories can be criticised for what could be perceived as an over-reliance on behavioural intentions as a determinant of behaviour. Models such as the TRA and the TAM have been found to reliably predict intention. However, even medium to large changes in intention have been found to result in only small to medium changes in behaviour (Webb & Sheeran, 2006). This finding supports the conceptualization of behaviour change as a two-stage process, the motivational stage which results in the formation of an intention, and the volitional stage which relates to performing the behaviour as intended (Heckhausen & Gollwitzer, 1987). The transition between these stages has been described as a change in mind-set, with the motivational stage characterized by weighing up different options and assessing the outcomes of different courses of action; and the volitional stage characterized by formulating a plan of action (Heckhausen & Gollwitzer, 1987). Models such as the TRA, TAM and UTAUT may, therefore, provide a good model of the motivational stage, but do not identify factors that might drive the volitional stage. How people set and achieve goals is a key research area in the volitional stage of behaviour change. Some authors have split this into two parts; goal setting and goal striving (Mann, de Ridder, & Fujita, 2013). Taking an intention, and setting a goal then needs to be followed by a period where the individual must put in effort to strive towards the goal, but also protect the goal from competing demands on attention and motivation. Augmenting goals with specific plans known as *implementation intentions* has been found to help people translate their intentions and goals into action (Gollwitzer, 1993). Implementation intentions are specific plans in the form of an if-then statement, for example 'if it is 5.30pm on Wednesday, then I will go to the gym'. Because such if-then plans clearly define both a suitable opportunity to act, and identify an appropriate goal-directed response to that opportunity, evidence suggests that that when the appropriate time comes, the behaviour is 'triggered' with minimal cognitive effort (Gollwitzer, 1999). Implementation intentions have been found to be more effective than more general goal setting such as 'I will increase my physical activity', furthermore they have been used to protect intentions from competing influences, making the achievement of the goals set more likely (Gollwitzer & Sheeran, 2006).

The theories mentioned above are only a small subset of the many theories that have been developed to explain how people change their behaviours. The Medical Research Council (MRC) 2008 guidance for developing and evaluating complex interventions (which encompasses BCIs) suggest using theory at all stages of intervention design, development, implementation and evaluation (Craig et al., 2008). By so doing, the reasons why a BCI works or does not work may be understood. However, using psychological theory in intervention design can be challenging (Michie & Prestwich, 2010; Michie, van Stralen, et al., 2011; Ogden, 2004). There are three main reasons for this: i) The number of potentially applicable theories, and component variables within these theories, is vast (Johnston & Dixon, 2008); ii) there is duplication present, with multiple theories incorporating the same concepts, sometimes using different terms (Michie et al., 2005); and iii) there is often little advice from authors in transferring the desired changes in theoretical components into practical strategies to incorporate into BCI design (Hardeman et al., 2002). As well as these problems originating from the theories themselves, there are also problems in the way that theories are currently used in BCIs. For example, sometimes when a theory is named in the published report, it is not clear how it influenced the design of the BCI and the description of published interventions frequently do not contain sufficient information to permit for replication (Hagger, 2009; Lippke & Zielgelmann, 2008; Michie, Fixsen, Grimshaw, & Eccles, 2009; Michie & Prestwich, 2010; Michie, van Stralen, et al., 2011; Schaalma & Kok, 2009).

Recent research has, however, focused on increasing the parsimony of psychological theories to reduce duplication and make these theories more useful in BCI development (Hagger, 2009). Lippke & Ziegelmann suggest that choosing one theory (while obviously essential for theory development work) might not result in the most effective interventions being designed and BCI developers should instead look at using 'theoretically derived behaviour change strategies which do not necessarily originate from one theory' (Lippke & Zielgelmann, 2008, p.701). In the same year, a taxonomy of behaviour change techniques (BCTs) was developed (Abraham & Michie, 2008). BCTs such as *prompt specific goal setting,* or *prompt self-monitoring of behaviour* were defined as the *active ingredients* of a BCI, and the aim was to enable a clearer explanation of how a BCI was developed and delivered, and therefore try to unpick what might be having an effect in a complex intervention. If, for example, effective BCIs contain BCTs A, B & C, and BCIs containing just BCTs A and B are not effective, then it suggests that BCT C drives the effectiveness of the intervention, and that this might be a beneficial BCT to investigate in future research. This is an over simplification as differences in target populations; implementation of the three BCTs; and whether it is the combination of BCTs that has the effect rather than one BCT alone, would all need to be considered (Abraham & Michie, 2008). Nevertheless, there is potential to gain an understanding of what components might be effective for certain groups of individuals in certain situations, which could then be used to develop new BCIs (Michie, Johnston, Francis, Hardeman, & Eccles, 2008). Using theoretically derived BCTs is a parsimonious way to approach BCI development, that moves away from the reliance on a single theory, and is both evidence-based and practically applicable (Hagger, 2009; Michie, Abraham, Whittington, McAteer, & Gupta, 2009).

Developers of BCIs can use the BCT taxonomy to assess which BCTs have been effective in the past. This approach, in a sense, is similar to the 'bottom-up' approach taken by the designers of persuasive technology, albeit with greater empirical evidence behind the techniques. While a BCI developer might end up with BCTs related to different theories, each used will have a reason *why* it is supposed to have an effect. There remains the problem of how to identify which BCTs or theories to use however.

A review in 2011 identified 19 frameworks that aimed to help BCI developers to implement psychological theory in practice, but found that none were coherent, comprehensive, and linked to an over-arching theory of behaviour (Michie, van Stralen, et al., 2011). Michie et al. therefore proposed a method for designing behaviour change interventions based on a wheel structure, that incorporated elements of the previous 19 frameworks, with an over-arching theory of behaviour (see Figure 1.6). At the centre, are the sources of behaviour that can be targeted by an intervention. Surrounding these are the approaches to consider when developing interventions; and finally, in the outer layer, are policy categories through which the intervention might be implemented (Michie, van Stralen, et al., 2011). In developing the 'Behaviour Change Wheel' (BCW) Michie et al. aimed to identify the fewest possible components that would explain the performance (or not) of a target behaviour and place them within a framework for intervention development that would encourage BCI developers to consider all options.

The over-arching model of behaviour was named the Capability, Opportunity, Motivation and Behaviour (COM-B) model (Michie et al., 2011), and is presented in Figure 1.6. The authors describe six variables in total: Psychological and physical capability; automatic and reflective motivation; and social and physical opportunity (Michie, van Stralen, et al., 2011; Porcheret & Main, 2011). The arrows show the potential effect that the different components can have on each other. Both capability and opportunity variables can influence motivation, and behaviour is thought to have a bi-directional relationship with all variables.

To summarise, the health psychology approach to developing BCIs suggests that a person passes through distinct phases when changing their behaviour, a motivational phase that leads to the formation of an intention, and a volitional phase that leads to the performance of the behaviour. Rather than choosing a single theory for either one of these phases (or the complete process), a developers of BCIs might choose a number of theory based BCTs to encourage change. Potentially effective BCTs can be identified from the existing literature by classifying interventions according to the BCT taxonomy. To provide a framework these BCTs can fit into, the BCW can be used to identify the characteristics of the behaviour, and the intervention functions that are likely to be effective.

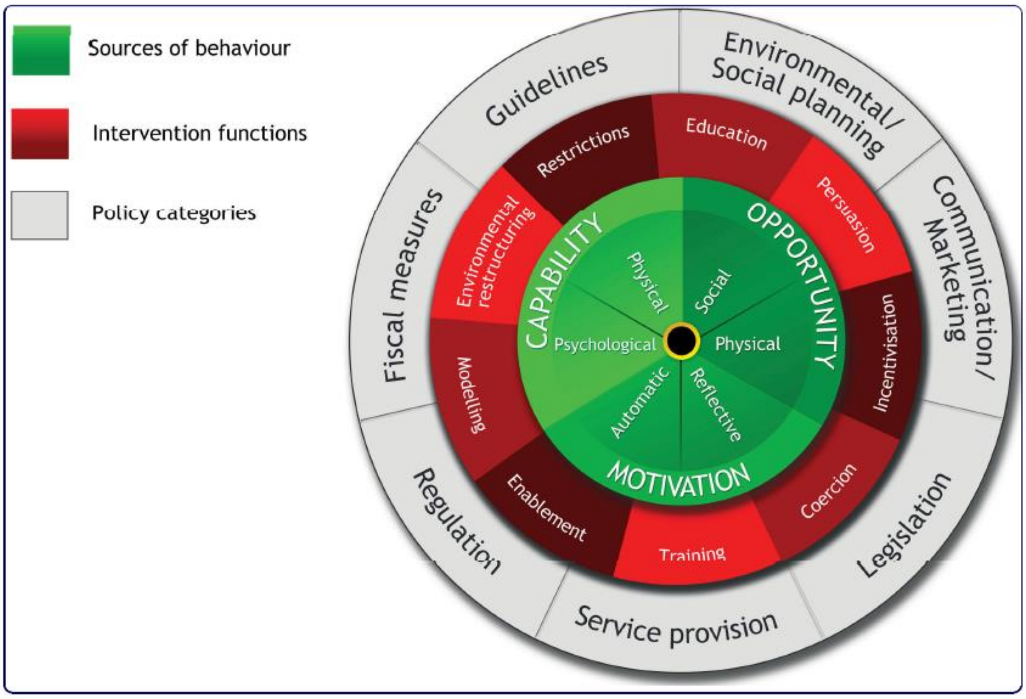

Figure 1.5: Behaviour Change Wheel. Reproduced with permission from (Michie, van Stralen et al. 2011)

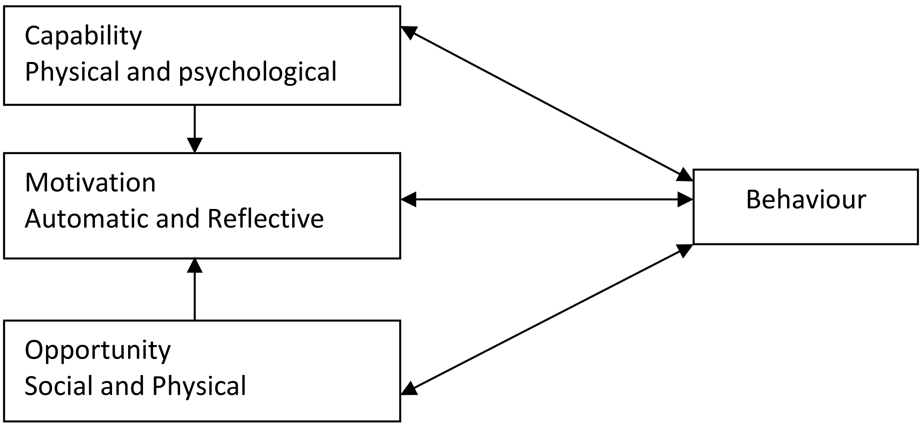

Figure 1.6: The COM-B Model from (Michie, van Stralen, & West, 2011)

1.1.5 Comparing and combining health psychology and persuasive technology approaches to BCI development

Combining the practical knowledge of the unique capabilities that technology has from the field of persuasive technology with an in depth understanding of behaviour and behaviour change from health psychology could potentially lead to the development of effective technology-based BCIs. Thus far, however, this combination of approaches has not been used for a chronic illness population (Riley et al., 2011). Although the approach taken by persuasive technology and that taken by health psychology have been developed independently, both fields have tried to identify the components that drive behaviour change. This has resulted in a taxonomy of behaviour change techniques, and a list of persuasive technology techniques, that are thought to be the ‘active ingredients’ of BCIs in both cases. In addition, both fields of research have tried to simplify their working model of behaviour, and have come to relatively similar conclusions.

The COM-B model (Michie et al., 2011) aims to simplify existing theories of behaviour change from health psychology and provides what can be termed ‘theoretical integration’ (Hagger, 2009) to provide researchers with a parsimonious model to use in BCI development. The FBM (Fogg, 2009b) was developed to explain the effectiveness (or not) of persuasive technologies. Both models agree that there are three key components that must be present for a behaviour to be performed: First, both models agree that motivation is necessary. Second, capability in the COM-B and ability in the FBM largely overlap, the difference being that ability, as specified in the FBM, incorporates the components of capability in the COM-B, as well as whether the user is able to perform the behaviour. In contrast, the COM-B defines whether the user is able to perform the behaviour as an opportunity component. The third component in each model is the trigger (FBM) or opportunity (COM-B). The trigger is something timely that needs to happen before the behaviour can be performed. Fogg describes the most appropriate triggers as being matched to the needs of the user. For example, if someone was able to perform the behaviour but lacked motivation, an appropriate trigger would increase motivation. However, if the person was already motivated and able to perform the behaviour, then an appropriate trigger might provide a reminder (Fogg, 2009a). The trigger is a multi-dimensional concept as it must do the right thing (e.g., either increase motivation or aid the user to translate an existing motivation into action) at the right time. The situational aspect to performing a behaviour overlaps with the opportunity component of the COM-B, described as ‘opportunity afforded by the environment’ (Michie et al., 2011, p.4) but the trigger also contains a more immediate aspect. In a sense the 'trigger' is more of a BCT that promotes behaviour – something to provide an extra push. Implementation intentions augment goal-setting and support goal-striving by linking an opportunity to act, with the desired action (Gollwitzer, 1993). This could also be seen as a way of triggering the behaviour.

This thesis aims to explore the potentially fruitful combination of persuasive technology and health psychology and apply it to behaviour changes that will promote effective self-management in PwCOPD. The following section will introduce COPD and the current approaches to treatment, and explore the technology that is currently used in this area.

1.2 COPD

1.2.1 Symptoms, Aetiology and Prevalence

COPD is a term used to describe patients with progressive, non-reversible airflow obstruction (DoH, 2004). This includes (but is not limited to) patients with diagnoses of emphysema and chronic bronchitis (National Clinical Guideline Centre, 2010). Physiologically it is characterised by 'an inappropriate/excessive inflammatory response of the lungs to respiratory pollutants mainly tobacco smoking' (Agusti, et al., 2003, p.347). While originally viewed as a disease of the lungs, the extra-pulmonary effects of COPD have also been recognised (Agusti, 2005). These are described as the systemic consequences of COPD and include skeletal muscle dysfunction, weight loss and nutritional abnormalities as well as increased risk of cardiovascular illness and osteoporosis (Agusti, 2005). Although the exact mechanisms behind these extra-pulmonary consequences are unclear, it is thought that systemic inflammation and the relative inactivity of COPD patients might contribute (Agusti, 2007), as well as the release of cytokines (Chung, 2001).

Around 80% of cases of COPD are linked to smoking (DoH, 2004); the other 20% can be attributed to a mix of environmental and genetic factors (National Clinical Guideline Centre, 2010). There are relatively few symptoms in mild disease, but as COPD progresses, symptoms include a chronic cough, sputum production, fatigue and shortness of breath (dyspnoea) (British Lung Foundation & British Thoracic Society, 2010; DoH, 2004). Patients typically experience periods of stability punctuated by exacerbations (sudden worsening of symptoms that can lead to hospitalisation, and worsening of baseline symptoms; British Lung Foundation & British Thoracic Society, 2010; DoH, 2004). As the disease progresses, exacerbations can become more frequent and/or more severe and the level of dyspnoea can become debilitating (Suter, Hennessey, Florez, & Newton Suter, 2011). In the short term, these symptoms can lower the patient's quality of life (QoL) and ability to perform activities of daily living such as washing, shopping, cleaning etc. (Suter et al., 2011). In the long-term they can lead to respiratory failure, patients requiring oxygen, and premature death (DoH, 2004).

Precise prevalence rates of COPD are difficult to ascertain. However, in a 2007 report from the British Lung Foundation it was estimated that, although 900,000 people in the UK were officially registered as having a diagnosis of COPD, due to the large numbers of people with undiagnosed COPD (Shahab, Jarvis, Britton, & West, 2006), the actual prevalence could be closer to 3.7 million (British Lung Foundation, 2007). COPD is the 2nd largest cause of emergency admissions in the UK (British Lung Foundation, 2007). It is anticipated that by 2020 COPD will be the 5th biggest cause of death worldwide (WHO, 2002). In 2004, COPD was estimated to cost the NHS £800million in direct care costs and was responsible for 24million lost work days (DoH, 2004).

1.2.2 Current Treatments for COPD

There is currently no cure available for COPD and, by definition, the damage to lung function is irreversible (DoH, 2004). Available treatments therefore aim to address the systemic consequences of COPD (Halpin, 2007), prevent or slow progression, alleviate symptoms, improve functioning, and reduce the likelihood of exacerbations resulting in hospitalisation. Current guidelines from the National Institute of Health and Care Excellence (NICE) advocate a multidisciplinary approach to treatment, with options being tailored to PwCOPD’s needs. The areas covered by the recommendations for the management of stable COPD are listed in Box 1. They cover a range of pharmacological and non-pharmacological approaches and highlight the complexity of ongoing care required by COPD patients. However, the success of COPD treatment depends on both professionals adhering to these guidelines (and the resources being available to support them in this), and PwCOPD initiating and maintaining a variety of self-management activities (National Clinical Guideline Centre, 2010). Experts in this area have identified five key self-management areas for PwCOPD: i) ‘Smoking cessation advice and support’ ii) ‘Self-recognition and treatment of exacerbations’ iii) ‘Exercise and increased physical activity’ iv) ‘Nutritional advice’ and v) ‘Dyspnoea management’ (Effing, et al., 2012, p.31).

Box 1. Areas covered by the recommendations for the management of stable COPD reproduced from 'Chronic obstructive pulmonary disease: Management of chronic obstructive pulmonary disease in adults in primary and secondary care: Updated guideline' (National Clinical Guideline Centre, 2010)

- Smoking Cessation
- Inhaled therapy
- Oral therapy
- Combined oral and inhaled therapy
- Oxygen
- Non-invasive ventilation
- Management of pulmonary hypertension and cor pulmonale
- Pulmonary rehabilitation
- Vaccination and anti-viral therapy
- Lung surgery
- Alpha-1 antitrypsin replacement therapy
- Multidisciplinary management (including, respiratory nurse specialists; physiotherapy; identifying and managing anxiety and depression; nutritional factors; palliative care; assessment for occupational therapy; social services ; advice on travel; education and self-management)
- Fitness for general surgery
- Follow-up of PwCOPD

The increasing focus on people with long-term conditions becoming more involved in the management of their own health is not unique to COPD (Department of Health, 2009). How this increased involvement is described, however, varies between sources. In the 'Your health-Your way' document the DoH use the term 'self-care', defined as encompassing self-management (Department of Health, 2009). Clark et al., however suggest that 'self-care' is focused on preventative activities, and is targeted more at healthy individuals, with no involvement from a health care professional (HCP). In contrast, the term self-management incorporates activities that aim to reduce the impact of an illness or disability (Clark et al., 1991). While these activities are performed by the individual at home, they are designed and supported by a HCP (Clark et al., 1991). In a review of self-management approaches for individuals with chronic illness Barlow et al., used the following definition of self-management:

> *'Self-management refers to the individual's ability to manage the symptoms, treatment, physical and psychosocial consequences and life style changes inherent in living with a chronic condition. Efficacious self-management encompasses [the] ability to monitor one's condition and to affect the cognitive, behavioural and emotional responses necessary to maintain a satisfactory quality of life. Thus, a*

dynamic and continuous process of self-regulation is established' (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002, p.178)

While this definition does not contain information about the involvement of HCPs it does provide an overview of the range of abilities that are needed by an individual to effectively self-manage their condition. It further describes the continued self-regulation through an ongoing process of monitoring and responding appropriately. Additionally, the definition encompasses the regulation of both behavioural and emotional responses. The authors of a 2009 Cochrane Review related to COPD use a similar definition:

'The idea of self-management is to teach patients the skills needed to carry out medical regimens specific to COPD, guide health behaviour change, and provide emotional support for patients to control their disease' (Effing et al., 2007, p.2) .

While Barlow et al's definition highlights the iterative nature of ongoing monitoring and adjustment that is necessary for self-regulation, Effing et al., highlight a separate iterative relationship, with self-management described as *providing* emotional support. This suggests that, as someone with COPD becomes more proficient in self-management, this will have positive effects not only on their health, but also their emotional wellbeing.

As the present research is focused on health behaviour change in those with COPD, the term self-management will be used as it is the more specific to those with long-term conditions. The key concepts of self-management as outlined above are; that it incorporates medical, behavioural and emotional aspects of living with COPD (Barlow et al., 2002; Effing et al., 2007); that it is an ongoing process that relies on continued self-regulation (Barlow et al., 2002); and that successful self-management can have positive effects on emotional wellbeing (Effing et al., 2007).

1.3 A review of technology based interventions for the self-management of COPD

In order to build on existing evidence of technology based interventions with PwCOPD, a brief systematic search with narrative review was conducted. The aim was to gain an understanding of the current research in the area, so that any successful elements might further inform the BCI development.

Search terms related to COPD (presented in full in Chapter 2) AND online OR web OR internet OR telehealth OR telecare OR telemedicine AND self-management OR self-care were entered in the Web of Knowledge (WoK) database (including WoK, MEDLINE and BIOSIS databases, all years), applicable reviews in the Cochrane library were also sought[2]. As this is a scoping review (Armstrong, Hall, Doyle & Waters, 2011), both reviews and studies of any design were included. Concern has been raised about commercially available mobile phone applications that aim to address health problems, with little evidence of their effectiveness (Rosser & Eccleston, 2011). Rosser et al., identified 111 applications that were aimed at patients and related to pain management (Rosser & Eccleston, 2011). In response to this, and to investigate if this is a potential concern for PwCOPD, following the same methodology as Rosser and Eccleston (2011) the iPhone App store, Google Play, Windows App Marketplace, Blackberry App World and the Nokia Ovi Store were all searched with the term COPD, and 'chronic obstructive'.

1.3.1 Reviews

There was 1 applicable Cochrane review (McLean, Nurmatov, Liu, Pagliari, Car & Sheikh, 2011) and 4 identified from the WoK search (Kobb, Chumbler, Brennan, & Rabinowitz, 2008; Osthoff & Leuppi, 2010; Smith, Elkin, & Partridge, 2009; Suter et al., 2011). The majority of the interventions described focused on the monitoring of symptoms and management of exacerbations as a way of reducing or avoiding hospitalisation. Common across all the reviews was a discussion of the heterogeneity of the research in this area. Heterogeneous areas included; COPD severity, outcomes measured and intervention characteristics such as the type of technology being used, and what non-technology based components the interventions contained (Kobb et al., 2008; McLean et al., 2011; Osthoff & Leuppi, 2010; Smith et al., 2009; Suter et al., 2011). As a minimum, the systems described collected some physiological data

[2] Two papers were also added that were identified in the systematic reviews presented in Chapters 2 and 3.

related to COPD and sent this to a health professional, but this could be in conjunction with face-to-face visits, indicating a variety of levels of automation. Both Suter et al., (2011) and McLean et al., (2011) commented that systems that rely on technology should only be introduced as part of an *integrated* health system but it was noted that, from a research perspective, this makes it difficult to ascertain the exact role that technology plays in any improvements (McLean et al., 2011) and within this, what the 'active components' of any intervention are (Osthoff & Leuppi, 2010).

Telehealth systems (i.e., systems that involve using technology to transfer data between the PwCOPD and the HCP) were found to be associated with a reduction in hospitalisations (McLean et al., 2011; Osthoff & Leuppi, 2010) and accident and emergency visits (McLean et al., 2011). However, the findings for other outcomes such as self-management (Smith et al., 2009) and QoL (McLean et al., 2011) were described in only cautiously optimistic terms, with authors stating there is "potential" for positive results from telehealth systems, but that the evidence is not currently available (McLean et al., 2011; Smith et al., 2009). The included reviews provided varied suggestions for future research. For some authors, large scale RCTs are suggested before further implementation (McLean et al., 2011; Smith et al., 2009), while others argued that the quasi-experimental studies already conducted are sufficient to begin introducing elements of these telehealth systems into mainstream healthcare (Kobb et al., 2008). There are limitations to both of these approaches – specifically, studies without control groups cannot rule out the possibility that any improvements are simply due to change over time, or other factors (McLean et al., 2011). However, large scale, well controlled trials are expensive and often not practical in an applied setting (Kobb et al., 2008). Furthermore, by following strict design protocols, such as excluding patients with co-morbid conditions, the results of large trials might not be representative of the COPD population (Smith et al., 2009). A balance between scientific validity and practicality is, therefore, suggested.

A number of authors called for more theoretically informed work to identify which components of the system might drive efficacy (McLean et al., 2011), and how (Smith et al., 2009). In a discussion of the level of control that PwCOPD take over their COPD, Smith et al., conclude that, while it is assumed by many that self-monitoring symptoms would increase PwCOPD's self-management skills, monitoring symptoms could just as easily have the opposite effect, and increase reliance on health professionals (through the technology) to manage the condition (Smith et al., 2009). This example highlights that there are still many questions to be answered about how PwCOPD respond to technology and the fundamental components of these systems, such as self-monitoring.

1.3.2 Empirical Studies, Pilot Studies and Usability Testing

Eighteen research studies were identified (see Appendix I: Table 1) As expected from the included reviews, the studies were heterogeneous in nature. There were two main aims of the technology used, i) to monitor symptoms, which allows for the early identification of exacerbations, and improved self-management of medication and ii) to increase physical activity; with some studies combining these aims. One study provided weather forecasts to help PwCOPD manage their medications, and one study described a system that was not integrated into the usual healthcare pathway but provided independently through a disease management organization. The mode of communication technology used varied greatly between the primary studies; the internet, landline telephone service (with either voice/button recognition for data entry), a videophone, some form of mobile device, either a PDA or mobile phone or the television were all used.

PwCOPD generally found the technology to be acceptable. However, in two studies, problems were noted regarding the accuracy of pedometers used (Koff, Jones, Cashman, Voelkel, & Vandivier, 2009; Moy et al., 2010), especially at slower walking speeds (Moy et al., 2010), and this resulted in participants finding the interventions less acceptable. Finkelstein et al., tested their 'Home Automated Tele-management' (HAT) system with a group of computer novices and found acceptability was high in this group only if they overcame their initial fear of technology (2003). Those that remained novice users, did not find the system acceptable. Burkow and colleagues found the television based 'MyHealthSystem' was acceptable to both PC and non-PC users (2008). It was also noted in one study that the satisfaction of PwCOPD was greater than health professional satisfaction following consultation by videophone (Mair et al., 2005). Acceptance is, therefore, a multi-faceted concept, and may differ between stakeholders; it is important for those who develop BCIs to consider this.

Problems with equipment failure were reported in three studies (Nguyen et al., 2008; Nguyen, Gill, Wolpin, Steele, & Benditt, 2009; Paget, Jones, Davies, Evered, & Lewis, 2010) which resulted in the early termination of one project (Nguyen et al., 2008), and difficulties in persuading users and staff to use equipment once the faults had been addressed in another (Paget et al., 2010). These findings highlight the importance of reliability in providing technology.

Effectiveness was reported in a sub-sample of the studies, for both objective and self-reported outcomes, although as most were pilot studies or small field tests, the results should be interpreted with caution. Two studies reported a reduction in hospitalisations following use of the technology (Koff et al., 2009; Paget et al., 2010), one an improvement in exercise capacity (Liu et al., 2008) and three reported improvements over time (not necessarily between groups) in the amount of physical activity performed (Moy et al., 2010; Nguyen et al., 2008; Nguyen et al., 2009). Self-report measures included improvements in QoL (Koff et al., 2009), self-efficacy to self-manage (Cummings et al., 2010) and one study that reported no improvement in management strategies on one site (Cooper & O'Hara, 2010), but promising results on another (Marno et al., 2010) following information relating to daily weather conditions.

1.3.3 Protocols and Conference Presentations

The two protocols identified by the literature search indicate that further evaluations of systems are being undertaken that will provide information relating to hospitalisation rates following use (Fitzsimmons, Thompson, Hawley, & Mountain, 2011; Pinnock et al., 2009), as well as other outcomes of interest such as QoL, self-efficacy, engagement/satisfaction with the technology, cost-effectiveness (Fitzsimmons et al., 2011; Pinnock et al., 2009), anxiety and depression (Pinnock et al., 2009) and accident and emergency admissions (Fitzsimmons et al., 2011). Abstracts reported in conference proceedings also indicate that ongoing innovative work is underway in the area of technology assisted COPD care. The approaches covered mirror those already described in the above papers, such as the development of voice recognition services to aid data input (Crespo, Sanchez, Crespo, Astorga, & Leon, 2010) and the development of a Smartphone application that links various input devices via Bluetooth for physiological data collection (Medvedev, Marshall, & Antonov, 2008).

1.3.4 Commercially available mobile phone applications

Only four applications were identified, and only two of these were aimed at PwCOPD. One was purely educational, providing information about COPD, coping skills and the importance of exercise (priced at 85p; KoolAppz, 2011). The app developers website did not suggest that any HCPs has been involved in the development of this app. The other was a 'COPD Tracker' and had three components: i) An educational component; ii) a tracking component to enable PwCOPD to record symptoms such as shortness of breath and sputum production so that these could be emailed to the user's HCP; and iii) a weather forecasting component that provided information about local air quality, wind and humidity (available for free; Everyday Health, 2011). This app was produced by 'Everyday Health', a website that provides information and support groups related to healthy living, and a range of conditions (www.everydayhealth.com. Accessed 11.10.11). The website is accredited by the Health on the Net Foundation, providing some credibility, and named HCPs can be identified. However, it is unclear from the website how involved these professionals had been during the development of the app. The other two applications were aimed at HCPs; one was educational (priced at £6.19; Expanded Apps, 2011), the other contained commonly used assessment scales for PwCOPD (priced at £3.99; Doctot, 2011).

In January 2012, the DoH released the findings of the 'maps and apps' project (Available at: http://webarchive.nationalarchives.gov.uk/20130402145621/http://mapsandapps.dh.gov.uk/). This project asked experts and the general public to suggest their favourite currently available health-related mobile phone applications, and to suggest possible future applications. Searching the term 'COPD' resulted in one relevant existing app, and eight ideas for future apps. The currently available app was a system developed by the NHS that used text messages for symptom reporting. The ideas for future apps included one aimed at HCPs, further development of the above NHS text message system, two ideas targeted at identification of early warning signs for exacerbations and advice on pharmacological management of these, and two targeted an increase in physical activity (Department of Health, 2012). The ideas that were submitted to the maps and apps project suggest a desire amongst stakeholders to have more comprehensive persuasive technology for the self-management of COPD than is currently available.

1.3.5 Discussion

Technology to change the behaviours of PwCOPD is a growing area, with two main focuses, both of which could be described as aiming to improve self-management. The first area relates to telehealth solutions that aim to encourage PwCOPD to monitor their symptoms themselves. There is evidence that this self-monitoring leads to earlier recognition of changes in condition, better medication management, and fewer hospitalisations (See Appendix I: Table 1). However, who drives these appropriate changes, and whether they increase self-efficacy for self-management or increase reliance on HCPs for decision making, is still uncertain (Smith et al., 2009). The second area is more focused on lifestyle modification. It was surprising that, given the broad search strategy used, only three areas of lifestyle modification were identified: Increasing physical exercise, breathlessness management, and improving medication management in response to changes in weather conditions. Despite the many mobile phone apps that are available for the general public to assist with lifestyle modification, surprisingly few related to COPD, although the findings of the maps and apps project indicate that this is an area that stakeholders would like to see further developed.

1.4 Aims and Objectives

The overall aim of this thesis is to explore the potential of evidence-based BCTs combined with persuasive technology to be accepted by, and to change the behaviour of, people with COPD. This aim will be addressed through meeting the following objectives:

1. To describe the evidence base and identify which BCTs have been most effective in changing behaviour in this population (Chapters 2 and 3).
2. To select an appropriate behaviour to target among PwCOPD (Chapters 2 and 3)
3. To assess the efficacy and acceptability of a simple persuasive technology that targets this behaviour with PwCOPD (Chapters 4 and 5).
4. To explore the opinions and preferences of key stakeholders towards the use of persuasive technology to increase the target behaviour (Chapters 6 and 7).

1.5 Methodological approach

In choosing a methodological approach for this thesis a balance was considered. Firstly, as identified in the above review, contradictory requests for future research to have both large trials and give greater understanding of how individuals respond to technology have been made. The balance between understanding individuals and producing results that can be generalized is, therefore, one of the methodological challenges in this area. Secondly, the 8-step design process (Fogg, 2009c) relies on fast iterations, until a collection of techniques are found that work. BCIs that target people with chronic illness(es), require adequate ethical approvals to be obtained ahead of implementation, and this can often take some time. Therefore, a balance must also be attained between research designs that are appropriate for PwCOPD, and those that are sensitive to the persuasive technology approach. To address this balance, a pragmatic approach is taken in this thesis, with the research questions leading the choice of an appropriate design, rather than any one underlying philosophical position (Seale, 1999). This approach allows for a mix of methods to be employed (i.e., both quantitative and qualitative) to understand the potential that persuasive technology may have in promoting behaviour change among PwCOPD. As well as enabling different types of questions to be answered, the findings of mixed methods research are thought to be greater than the sum of their parts (Bryman, 2007; Creswell & Plano Clark, 2011; O'Cathain, Murphy, & Nicholl, 2010). As a range of methods will be used, rather than provide a rationale and explanation for each in a single methodology chapter, the methodology used for each study will be presented before the results of that study are reported (in Chapters 2, 3, 4 and 6).

2 Study 1: Effective Behaviour Change Techniques in Smoking Cessation Interventions for People with Chronic Obstructive Pulmonary Disease (COPD): A Meta-Analysis.

2.1 Introduction

In Chapter 1 (Section 1.2) the complex nature of COPD care, and the range of components necessary for effective self-management were introduced. Many of these components require the person with COPD to change their behaviour, and therefore could be targeted by a technology based BCI. Ideally the behaviour targeted would be a common problem for people with COPD, this would ensure the intervention would be relevant to a wide range of people with COPD, and that when recruiting a small number of people (as in Chapter 4), there would be a high chance that all those recruited would need to change this behaviour. Target behaviours must also have measurable outcomes within a reasonable timescale. An initial scoping review of the evidence in this area suggested several potential targets for a self-management BCI; medication adherence; formulating and following action plans for exacerbation management; breathing training; nutritional advice; smoking cessation and increasing physical activity (as discussed in Section 1.2.2)

Of these, medication adherence, exacerbation management and nutritional advice were deemed unsuitable. With the wide range of medications currently available to PwCOPD, there would be too much variation in the advice needed for medication adherence to be feasible. Behavioural outcomes for exacerbation management can only be measured in the case of an exacerbation, this might result in too long a time period between intervention and outcome measurement. And nutritional advice for PwCOPD can be either to lose weight or to gain weight meaning two very different interventions would be needed to address this. Therefore, the remaining three lifestyle modification behaviours were considered; smoking cessation; increasing physical activity; and breathing training.

To assess the current literature in this area and identify how successful any format of intervention (i.e. not limited to technology) had been in changing these target behaviours in people with COPD systematic reviews with meta-analyses were conducted. In addition, evidence-based BCTs used in previous interventions were identified and assessed for effectiveness. Following the initial search, it was decided that a separate review of breathing training interventions wouldn't be necessary for two reasons; first, a protocol for a Cochrane Review was identified with the objective of investigating the clinical utility of breathing training for PwCOPD as current results are equivocal (Holland, Hill, & McDonald, 2010), this risked duplication of work. Secondly, the breathing techniques, once learnt, are used as and when they are needed, therefore many of the interventions lacked measurable behaviour change outcomes. The breathing training interventions that met the criteria for the review of physical activity interventions were included in this. This chapter reports the review of interventions targeting smoking cessation (Bartlett, Sheeran, & Hawley, 2013) and Chapter 3 describes the review of interventions targeting physical activity (with eligible breathing training papers).

2.1.1 Background: Smoking cessation for people with COPD

Approximately 80% of cases of COPD are linked to smoking (DoH, 2004). To date, the only intervention found to slow the characteristic decline in lung functioning is smoking cessation (Anthonisen et al., 1994). Current best practice is to encourage people with COPD to quit smoking and give all the necessary psycho-social and/or pharmacological support that might be needed (National Institute of Health and Care Excellence, 2010a). Nevertheless, the proportion of people with COPD who continue to smoke has been estimated between 32.8% and 70% (Baron, 2003; Vozoris & Stanbrook, 2011) and could be rising (Vozoris & Stanbrook, 2011). The current advice to physicians in the UK and the USA is that people with COPD should be given advice at every opportunity and, if the person is agreeable, should be referred to a local smoking cessation service (National Institute of Health and Care Excellence, 2010a; Parker & Eaton, 2012). In the UK this is the NHS Stop Smoking Services [SSS]. Target quit rates for the NHS SSS are between 35% and 70% (Willis, 2008). However, the SSS are not specifically designed for people with COPD. Evidence suggests smokers with COPD have greater dependence on nicotine than those with normal lung functioning (Jiménez-Ruiz et al., 2001), and find it harder to quit (Tashkin & Murray, 2009). Continued smoking by people with COPD increases hospital admissions and negatively affects morbidity and mortality (Global Initiative for Chronic Obstructive Lung Disease (GOLD; 2011). In a recent simulation, it was estimated that continued smoking by people with COPD in England alone would result in costs of £1,657 million over a 10-year time period, and that smoking cessation was cost-effective regardless of disease stage (Atsou, Chouaid, & Hejblum, 2011). Despite the health and economic benefits of smoking cessation in this population, there is relatively little evidence of smoking cessation interventions that are tailored for this group (Parker & Eaton, 2012).

2.1.2 Rationale for the Present Review: Identifying Effective Behaviour Change Techniques

Previous systematic reviews addressing smoking cessation in people with COPD have concluded that a combination of stop smoking medication (SSM) and non-pharmacological approaches offers the most effective smoking cessation intervention for people with COPD. This finding has been supported by meta-analyses (van der Meer, Wagena, Ostelo, Jacobs, & van Schayck, 2003; Strassmann et al., 2009), economic modelling (Hoogendoorn, Feenstra, Hoogenveen, & Rutten-van Molken, 2010), and narrative review (Parker & Eaton, 2012; Warnier, Riet, Rutten, Bruin, & Sachs, 2012). However, although the SSM components have been ranked in terms of effectiveness (Strassmann et al., 2009), the efficacy of the non-pharmacological components (typically referred to as 'behavioural counselling') has not previously been assessed. What constitutes 'behavioural counselling' varies considerably between interventions (Michie & Abraham, 2008). Parker & Eaton (2012) suggest that counselling 'should assist in motivating the smoker to quit smoking and developing skills and strategies to cope with nicotine withdrawal, and…should also help the smoker identify cues and situations that would lead to temptation or pressure to smoke' (p. 161) though they did not describe which of the existing interventions contain these elements, or their potential relationship with intervention outcomes.

In addition to the taxonomy of BCTs that was developed by Abraham and Michie and introduced in section 1.1.4; Michie and colleagues have produced a taxonomy of the BCTs used specifically in smoking cessation studies (Michie, Ashford, et al., 2011; Michie, Hyder, Walia, & West, 2011). Michie et al.'s (2011) taxonomy contains 53 BCTs categorised into groups according the function they perform (see Table 2.1). Techniques coded with a 'B' have a specific focus on behaviour and are split into 'BM' (which address motivation) and 'BS' (which focus on self-regulatory capacity and skills). 'A' codes promote adjuvant activities and 'R' codes focus on more general aspects of the interaction; 'RD' describing aspects of delivery, 'RI' aspects of information gathering and 'RC' general communication (Michie, Hyder, et al., 2011). These groups outline the target areas for smoking cessation counselling. However, within these codes, the taxonomy defines specific BCTs used to achieve these targets (see Table 2.1 for examples). This taxonomy has been used to classify interventions and services for the general population of smokers (West, Walia, Hyder, Shahab, & Michie, 2010), the content of a text message-based intervention for smoking cessation (Michie, Free, & West, 2012), and smoking cessation interventions for pregnant women (Lorencatto, West, & Michie, 2012). This method has not heretofore been applied to smoking interventions among people with COPD.

The purpose of the present review is to identify which BCTs are associated with more effective smoking cessation interventions for people with COPD. Discovering effective BCTs could guide the development of future interventions tailored to the COPD population, to ensure maximum impact on cessation rates.

Table 2.1: Smoking Cessation Taxonomy from Michie, Hyder et al., 2011

		Example Code	*Example BCT*	*Example Description*
(B) Specific focus on behaviour	*(M) Addressing Motivation*	BM1	Provide information on the consequences of smoking and smoking cessation	Give, or make more salient, information about the harm caused by smoking and the benefits of stopping; distinguish between the harms from smoking and nicotine; debunk myths about low tar and own-roll cigarettes and cutting down
		BM4	Provide rewards contingent on succesfully stopping smoking	Give praise or other reqards if the person has not smoked
	(S) Maximising self-regualtory capacity/ skills	BS1	Facilitate barrier identification and problem solving	Help the smoker to identify general barriers (e.g. susceptibility to stress) that might make it harder to stay off cigarettes and develop general ways of addressing these
		BS4	Facilitate goal setting	Help the smoker to set a quit date and goals that support the aim of remaining abstinent
Promote adjuvant activities		A1	Advise on stop-smoking medication	Explain how the benefits of medication, safety, potential side effects, contra-indications, how to use them most effectively, ad how to get them; advise on the most apprpriate medication for the smoker and promote effective use
		A4	Ask about the experiences of stop smoking medication that the smoker is using	Assess usage, side effects and benefits experienced of medication(s) that the smokeris currently using

(R) General aspects of the interaction	*(D) Focusing on the delivery of the intervention*	RD1	Tailor interactions appropriately	Use relevant information from the client to tailor the behavioural support provided
		RD2	Emphasise choice	Emphasise client choice within the bounds of evidence based practice
	(I) Focusing on information gathering	RI1	Assess current and past smoking behaviour	Assess amount smoked, age when started, pattern of smoking behaviour
		RI4	Assess withdrawal symptoms	Assess the presences and severity of nicotine withdrawal signs and symptoms
	(C) Focusing on general communication	RC1	Build general rapport	Establish a postive, friendly and professional relationship with the smoker and foster a sense that the smoker's experiences are understood
		RC4	Explain expectations regarding the treatment programme	Explain to the smoker the treatment programme, what it involves, the active ingredients and what it requires of the smoker

2.2 Method

2.2.1 Search Strategy

The present review was part of a larger review of behaviour change interventions in people with COPD. Briefly, the search strategy comprised of COPD terms AND intervention/behaviour terms AND smoking terms OR exercise terms OR breathing training terms (for the full strategy, see Table 2.2). The full search strategy (optimised for each database) was run in CINAHL, MEDLINE, PsycINFO, Web of Knowledge (all databases) and EMBASE. Articles that cited, or were cited by, included studies and applicable reviews were assessed. A reduced search (COPD AND behav$) was conducted in PASCAL, ESTAR, AMED, and the Applied Social Sciences index and abstracts. A search limited to smoking terms, consisting of 7 AND 11 AND 13 in Table 2.2 was last updated on 27/12/2012.

Table 2.2: Search strategy for BCT systematic research review

Row	Search terms
1	Lung disease*, obstructive (mapped to subject heading where applicable)
2	Pulmonary disease, chronic obstructive (mapped to subject heading, exploded if applicable)
3	Emphysema*
4	(chronic adj3/N3 bronchitis*)
5	(obstruct* adj3/N3 (lung* or airway* or airflow* or bronch* or respirat*))
6	COPD or COAD or COBD or AECB
7	1 or 2 or 3 or 4 or 5 or 6
8	Exercise or 'exercise movement therapy' or 'exercise therapy' or kinisio*therapy
9	(physical or exercise)adj/N1 (train* or fitness or activit* or therap*)
10	8 or 9
11	Abstain* or smok* or giv* or tobacco* or nicotine* or anti*smoking or quit* or stop* or cessat* or ceas* or abstin*
12	Pursed lip breath* or diaphragm* breath or breath* or inspiri* or 'ventilation feedback training' or yoga or 'chest physiotherapy' or 'chest physical therapy'
13	Behave* or intervention*
14	10 or 11 or 12
15	7 and 13 and 14

2.2.2 Inclusion and Exclusion Criteria

Papers were included if (a) smokers with a diagnosis of COPD were participants, (b) a randomised controlled trial (RCT) of an intervention that aimed to alter participants' behaviour was reported, and (c) a measure of smoking cessation was reported. Unpublished papers and papers not written in English were excluded.

2.2.3 Outcome Definitions

The outcome of interest was smoking cessation (quit rate), measured by either point prevalence (PP) or continuous abstinence (CA) measures. PP measures smoking status at a specific point in time, or for a period immediately before this point; typically these measures assess whether or not the person has smoked in the last 7 days. CA measures sustained abstinence over a longer period of time, with smoking status measured on two or more occasions. Both CA and PP can be assessed using self-report, biochemical validation, or both.

2.2.4 Quality Assessment

Study quality was assessed using the Delphi List (Verhagen et al., 1998), see Appendix I: Table 2. Scored from 0 to 9, a score of five or greater indicates a 'high quality study' according to a related Cochrane review (van der Meer et al., 2003). Power and attrition rates were also calculated for each study.

2.2.5 Coding of Interventions

Interventions were coded according to a 53-item taxonomy that is specific to smoking cessation (Michie, Churchill, & West, 2011). To ensure comprehensive coding of the interventions, authors were contacted for any additional materials such as protocols or training materials. Any English language resources provided were coded in addition to the publication. Intervention descriptions were coded by a researcher familiar with the taxonomy who had undergone training in the use of BCT taxonomies. Fifteen of the 17 interventions were further independently coded by an expert in using this taxonomy. Initial agreement between the two coders was 89% with a Kappa coefficient of 0.7. This represents “substantial agreement” (Landis & Koch, 1977). Disagreements were resolved by discussion.

The BCT taxonomy contains several codes related to SSM, namely, *advise on stop smoking medication*, *adopt appropriate local procedures to enable clients to obtain free medication,* and *ask about experiences of stop smoking medication that the smoker is using*. However, these codes do not differentiate between SSM being a prescribed, integral part of the intervention, and advice and free SSM being provided (or suggested) for use at the participant’s discretion. For this review studies that used SSM as a mandatory part of the intervention protocol (including prescribed doses) were additionally coded as ‘SSM’ studies. A further three COPD-specific BCTs were identified, namely, *COPD medication advice*, where advice was given regarding non-study medication that is not SSM (e.g., advice on, or optimisation of COPD-related medication), *COPD-specific information* where advice about areas of COPD management in addition to smoking cessation is given (e.g., breathing training) and *Linking COPD and smoking* where an explicit link is drawn between the participant’s smoking and their COPD (e.g., referring to the participant as having ‘smoker’s lung’).

2.2.6 Assessment of Effectiveness and Meta-Analytic Strategy

The effectiveness of smoking cessation interventions was assessed by two indices, the sample-weighted quit rates and sample-weighted effect sizes (d_+). Both indices were computed using the point prevalence (PP) and continuous abstinence (CA) rates. If PP and CA rates were both reported, the outcome with the highest ranking according to (Eisenberg et al., 2008) was used to calculate the most conservative estimate for each study. Eisenberg et al. ranked biochemically validated CA at 12 months most highly, followed by CA at 6 months, followed by PP at 12 months and finally PP at 6 months. Effect sizes were calculated using META 5.3 (Schwarzer, 1987). Random effects models were used as it is assumed that there will be unmeasured variance between the studies in the sample. STATA Version 11 was used to generate the funnel plot and to estimate small-sample bias via Egger’s regression.

Potential moderators of effectiveness considered were BCTs used, study quality, study design, intervention features, type of outcome measure, and the use of SSM. For dichotomous moderators (e.g., presence vs. absence of a specific BCT), the average effect size was computed when there were at least three independent tests for both levels of the moderator, and the between-groups heterogeneity statistic (Q_b) was used to compare the effect sizes (Webb & Sheeran, 2006). Associations between continuous moderator variables and effect sizes were computed using Weighted Least Squares (WLS) regression in SPSS (i.e., effect sizes were weighted by the respective sample *n*).

2.3 Results

2.3.1 Studies Included in the Review

The flow of articles through the review is shown in Figure 2.1. A total of 17 eligible interventions were identified with a total sample of 7446 people with COPD (see Appendix I: Table 3). Mean age ranged from 48 to 67 years old; 43% of the overall sample was female (see Appendix I: Table 4). In studies reporting FEV_1%pred[3], values ranged from 52% to 80% (k = 8) which is considered moderate severity according to the GOLD (2011) standards.

Intervention duration ranged from 22 days to 5 years (*Mdn* = 85 days; k = 12). The longest follow-up (after all active components of the intervention had stopped) ranged from immediately to 2 years (k = 13). The main delivery modes (k = 17) were one-to-one (71%) or a mixture of both one-to-one and group delivery (29%). Intervention setting (k = 17) varied between studies; 65% had at least some of the components delivered in the participant's home, and 35% were delivered exclusively in a clinical setting (see Appendix I: Table 3).

2.3.2 Quality Assessment

Overall, 59% of studies (k = 10) reached the ≥ 5 threshold for high quality used by van der Meer et al., (2003). The average quality rating overall was 5.47 (*SD* = 2.29) (see Table 3.1). Ten studies reported an *a priori* power calculation to identify a desired sample size, though only five of these studies reached their target sample size. Post-hoc power could be calculated for 15 studies; power ranged from 8% to 100% with an average of 63% (*SD* = 0.30). Ten studies reached the threshold for adequate power (55%) suggested by Coyne, Thombs and Hagedoorn (2010). Attrition rate was the percentage of randomised participants who began the

[3]Forced Expiratory Volume in one second, presented as a % of what would be expected for someone of the same age, gender and height

intervention, but did not complete the longest follow-up (*M* = 17.46%, *SD* = 10.53). Where reported, mean drop-out during the intervention period was 16.69% (*SD* = 15.69). Overall, the quality of studies included in the review could be considered satisfactory (see Table 3.1).

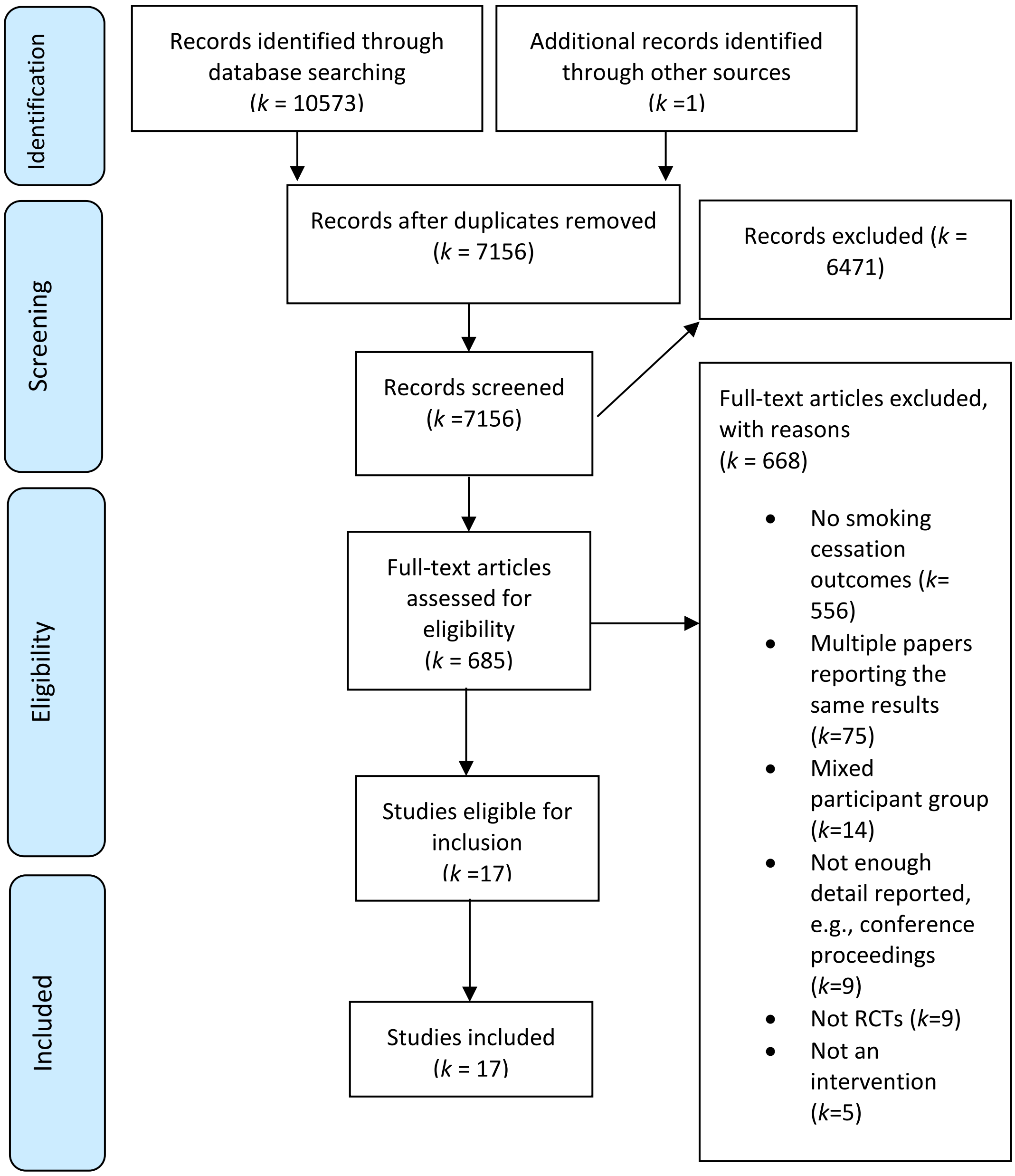

Figure 2.1: Flow of Articles through the Phases of the Present Review

2.3.3 Effectiveness of Smoking Cessation Interventions

Individual study quit rates ranged from 0% (Wilson et al., 2008) to 28.9% (Brandt et al., 1997). The overall sample–weighted average quit rate was 13.19%. The sample-weighted average effect size (d_+) was 0.33 (see Table 2.4). The 'Lung Health Study' study had a very large sample size and longer follow-up period compared to the other studies (Anthonisen et al., 1994). However, deleting this study did not significantly change the average effect size ($d_+ = 0.31$) or improve homogeneity. The effect size for the 9 studies with adequate power was .37; this value did not differ significantly from studies with inadequate power ($d_+ = 0.22$). The funnel plot appeared symmetrical (see Appendix I: Figure 1), and Egger's regression revealed no significant bias in the observed effect sizes ($\beta = -1.06$, $SE = 0.58$, *ns*). These findings suggest that publication bias does not present a problem for the present meta-analysis.

Potential moderators of the observed effect sizes were tested using the Q_b statistic (see Table 2.4). The effect size for measures of CA ($k = 11$, $d_+= 0.42$) was higher than those studies reporting only PP ($k = 6$, $d_+ = 0.29$), but the difference did not reach significance ($Q_b = 3.58$, $p = 0.06$). The nature of the comparison group (usual care vs. placebo) did not influence effect sizes (see Table 2.4). However, the provision of stop smoking medications (SSM) and both delivery and setting of the interventions was a significant moderator. Interventions that provided SSM as a mandatory part of their protocol ($k = 7$, $d_+ = 0.42$) were more effective than interventions that did not ($k = 10$, $d_+ = 0.32$), $Q_b = 26.24$, p<0.001. Interventions delivered exclusively in a clinical setting ($k = 6$, $d_+ = 0.37$) had a significantly higher d_+ than those that contained either home components, or were delivered exclusively at home ($k = 11$, $d_+ = 0.28$), $Qb = 13.34$, p<0.001. Interventions containing group components ($k = 4$, $d_+ = 0.49$) had a significantly higher effect size than one-to-one only interventions ($k = 12$, $d_+ = 0.26$), Qb = 49.77, p<0.001. Potential continuous moderators were entered into WLS regressions. Study quality (k =17, $\beta = 0.27$, $p = 0.30$), duration of the intervention ($k = 13$, $\beta = 0.48$, $p = 0.10$), the time between the end of the intervention to the longest follow-up ($k = 13$, $\beta = 0.07$, $p = 0.82$) and attrition rate (k= 17, $\beta = -0.245$, $p = 0.34$) did not significantly predict effect sizes.

2.3.4 Behaviour Change Techniques and Intervention Effectiveness

Of the 53 smoking cessation Behaviour Change Techniques (BCTs) identified by Michie, Churchill, and West (2011), 47 were used in one or more of the interventions. The number of techniques used in each intervention ranged from 1 to 28, with an average of 13.11 ($SD = 8.63$; see Appendix 1: Table 3). The most frequently used individual technique was *Boost motivation and self-efficacy*, which was used in 71% of the interventions.

The impact of presence versus absence of particular BCTs on effectiveness was tested using the Q_b statistic (see Table 2.4). Two techniques were associated with reduced effectiveness (*Boost motivation and self-efficacy* and *Assess nicotine dependence*). However, there were positive effects for four techniques: Interventions that deployed *Facilitate action planning/develop treatment plan*, *Prompt self-recording*, *Advise on methods of weight control*, and *Advise on/facilitate use of social support* each engendered significantly larger effect sizes compared to studies that did not use these techniques.

Two groups of BCTs had ≥ 3 studies in both presence and absence levels to be analysed. Interventions that used BCTs focussing on self-regulatory capacity/skills (BS codes) and interventions that promoted adjuvant activities (A codes) were compared with interventions that did not; neither comparison was significant ($Qb = 1.13$, $p = 0.29$ and $Qb = 0.89$, $p = 0.34$ respectively). The provision of *COPD-specific information* or *COPD medication advice* was not associated with effect sizes ($Qb = 1.35$, $p = 0.25$ and $Qb = 0.02$, $p = 0.88$, respectively). However, interventions that involved *Linking COPD and smoking* generated larger effect sizes ($Q_b = 8.42$, $p < 0.01$).

2.4 Discussion

Seventeen RCTs of smoking cessation interventions for people with COPD were identified. The sample-weighted average quit rate across these trials was 13.19%. This rate is higher than the 5% expected quit rate for general population smokers with no help (Hughes, Keely, & Naud, 2004), marginally higher than the 12.3% quit rate reported in a previous review of people with COPD (Hoogendoorn et al., 2010)**,** and lies within the range of general population quit rates in response to behavioural interventions for smoking (Poulsen, Dollerup, & Moller, 2010). It has been reported that people with COPD find it harder to quit than the general population of smokers (Tashkin & Murray, 2009), so it was expected that the quit rate observed here (13%) falls below the minimum expected quit rate of 35% in the Stop Smoking Services (SSS; Willis, 2008), and below the actual quit rate of 49% achieved by NHS SSS across England in 2011/2012 (Health and Social Care Information Centre, 2012). It is notable that no statistics are available for quit rates for people with COPD through the SSS. However, the relatively high prevalence of COPD suggests that even a quit rate of 13% would be important for healthcare services (Tashkin & Murray, 2009; West, 2007). The magnitude of the sample-weighted average effect size is also consistent with the idea that smoking cessation interventions for people with COPD were generally effective. The effect size observed here ($d_+ = 0.33$) is in the modal range obtained in a review of 302 meta-analyses of psychological and behavioural treatments (Lipsey & Wilson, 1993).

Interventions containing group elements and those delivered within a clinical setting were found to be effective in this population. The increased benefit of including group elements, over and above individual counselling, in smoking cessation interventions for the general population is currently unclear (Stead & Lancaster, 2009). Further research is needed to ascertain whether this approach is more effective for people with COPD than the general population of smokers. Smoking cessation interventions delivered while PwCOPD are hospitalised, with a range of conditions, and containing follow-up extending beyond the period of hospitalisation have been found to be more effective than usual care in a meta-analysis (Munafò, Rigotti, Lancaster, Stead, & Murphy, 2001). Clinical settings are smoke-free environments, and all other cues to smoking associated with being in the home would be removed in these interventions; these additional factors may have contributed to interventions delivered in a clinical setting being more effective for people with COPD.

A novel feature of the present meta-analysis was that the BCTs used in smoking cessation interventions for people with COPD were coded, and their impact on effectiveness was tested. Across all 17 interventions, four established BCTs were associated with significantly larger effect sizes: *Facilitate action planning/develop treatment plan*, *Prompt self-recording*, *Advise on methods of weight control*, and *Advise on/facilitate use of social support*. In addition, one new COPD-specific BCT *Linking COPD and smoking* was also found to be associated with larger effect sizes. As introduced in Section 1.1.4, forming a detailed plan of what, when and how to achieve a behaviour change has been found to be effective in achieving a wide range of behaviour change targets (Gollwitzer & Sheeran, 2006). Implementation intentions take the format of if-then plans and have been found to be effective not only in promoting initial changes in behaviour (e.g., Sheeran & Orbell, 1999)but also in protecting ongoing behavioural performance from antagonistic feelings and cognitions (e.g., Achtziger, Gollwitzer, & Sheeran, 2008; Martin, Slade, Sheeran, Wright, & Dibble, 2011). The current findings suggest that prompting the formation of if-then plans, providing information about how to handle weight gain as a possible side-effect of cessation, and facilitating self-monitoring of current behaviour and progress towards the goal could each constitute useful components of smoking cessation interventions for this population.

Table 2.3: Intervention Outcomes

Authors	*Quality Score*[†]	*Cessation measure*[††]	*Cessation criteria*	*A priori sample size required*	*Attrition rate %*	*N Experimental*	*N Control*	*Quit % Experimental*	*Quit % Control*	*d*	*Post-hoc power*[†††]
Anthonisen et al.,1994	5	CA	Cotinine levels of <20ng/mL or, if using NRT exhaled CO<10ppm.Stopped smoking in the initial intervention and maintained this status	4000	3.5	1961	1964	20.80	5.20	0.48[a]	1
Borglykke et al.,2008	6	PP	Self-reported, validated by carboheamoglobin<2%	NR	0	121	102	29.75	12.75	0.42	0.75
Brandt et al., 1997	2	PP	Self-reported validated by CO at the final follow-up	NR	6.25	20	25	40	20	0.45	0.43
Christenhusz et al.,2006	4	CA	Self-reported continuous for 12 months, validated by cotinine <20ng/ml at 6 and 12 months (must have at least 4 days abstinence for this to occur)	162	6.67	105	105	19.05	8.57	0.31	0.72
Crowley et al.,1995	4	PP	Self-reported abstinence for 24 hours, CO<10ppm	NR	26.53	18	15[b]	NR 15.15 total	NR 15.15 total	0[c]	NC
Efraimsson et al., 2008	4	PP	‘Do you smoke?’ yes/no	NR	19.23[d]	16	14	37.5	0	1.06	0.88
Hilberink et al.,2011	5	PP	Self-reported, did not smoke in the last 7 days, verified by urinary Cotinine <50ng/mL	300	4.3	519	148	7.51	3.38	0.14	0.56
Khdour et	4 [e]	CA	Self-reported as in the	160	17.34[d]	18	19	22.22	10.53	0.32	0.24

Authors	*Quality Score*[†]	*Cessation measure*[††]	*Cessation criteria*	*A priori sample size required*	*Attrition rate %*	*N Experimental*	*N Control*	*Quit % Experimental*	*Quit % Control*	*d*	*Post-hoc power* [†††]
al.,2009			maintenance stage from a stages of change questionnaire at 12 months								
Kotz et al. , 2009	5	CA	Abstinence at weeks 5, 26 and 52 validated by urinary cotinine <50ng/mL	168	15.76	116	68	11.21	5.88	0.19	0.36
Pederson et al.,1991	3	CA	Self-reported quit smoking for 6 months, random sample verified by Carboxyhaemoglobin levels in a blood sample	74	21.62	30	28	33.33	21.43	0.27	0.26
Sundblad et al.,2008	3	CA	Self-reported abstinence for the last 6 months. N=35 CO tested for <8 ppm	NR	18.2	192	199	38.02	10.05	0.7	1
Tashkin et al., 2001	9	CA	0 cigarettes from week 4-26 verified at each clinic visit by exhaled CO≤10ppm	400	31.19	204	200	15.69	9.0	0.20	0.64
Tashkin et al., 2011	9	CA	Self-reported abstinence from week 9-52, validated at each clinic visit, CO≤10ppm	500	33.93	248	251	18.6	5.6	0.41	1
Tønnesen et al.,2006	9	CA	Self-reported abstinence from week 2- month 12. Verified at each clinic visit by carbon monoxide <10ppm	268	22.16	185[f]	185[g]	14.05	5.41	0.29	0.87

Authors	*Quality Score*[†]	*Cessation measure*[††]	*Cessation criteria*	*A priori sample size required*	*Attrition rate %*	*N Experimental*	*N Control*	*Quit % Experimental*	*Quit % Control*	*d*	*Post-hoc power*[†††]
Wagena et al., 2005	9	CA	Self-reported complete abstinence from week 4 to week 26 after quit date, confirmed by urinary cotinine of =<60ng/mL at weeks 4, 12 and 26 post quit date.	300	<5%[d]	96[h]	48	25[i]	8.33	0.38[j]	0.73
Wilson et al., 2008	6	CA	Complete cessation for all visits. Verified by exhaled CO≤10ppm and salivary cotinine ≤ 10ng/ml	303	25.27	56[k]	35	0	0	0[l]	NC
Zwar et al., 2012	6	PP	Smoking status at 12 months, no further detail given		27.41	74	61	14.86	16.39	0.04	0.08

Note: [†]Results from the Delphi List quality assessment (Verhagen, de Vet, de Bie, Kessels et al., 1998);[††] In studies where both CA and PP were reported, CA was used ;[†††]Calculated post-hoc from http://www.danielsoper.com/statcalc/calc49.aspx one-tailed, using total sample size, *d* and an alpha level of 0.05; [a] Bronchodilator vs. Usual care; [b] Control group only, excluding self-report; [c] Estimated, no significant difference between groups; [d] For whole sample; [e] Minimisation counted as equivalent to randomisation; [f] Sum of high and low support with NRT as there were no significant differences between groups; [g] Sum of high and low support with placebo as there were no significant differences between groups; [h] Bupropion and Nortriptyline; [i] Total quit rate for Bupropion and Nortriptyline; [j] Combined Bupropion and Nortriptyline vs. placebo; [k] Combined individual and group support groups; [l] Estimated 0 quit smoking in either group not reported for smokers only; Ne = Number in experimental group; Nc = Number in control group NR = not reported PP=Point Prevalent CA = Continuous Abstinence CO = Carbon Monoxide, NC= not calculable, ppm=parts per million

Table 2.4:Overall Effect Sizes, Homogeneity, and Moderator Analyses

				95% Confidence Intervals		*Homogeneity Analysis*	
Measure	*k*	*n*	*d_+*	*Lower*	*Upper*	*Qw*	*Qb*
Overall	17	7446	0.33	0.23	0.43	41.55***	
Outliers							0.23
Excluding Anthonisen et al.,1994	16	3521	0.31	0.20	0.42	29.92*	
Quality							3.10
Adequate power and sample size[1]	9	6833	0.37	0.27	0.48	26.7***	
Inadequate power and sample size[1]	8	613	0.22	0.00	0.43	7.28	
Intervention Design [2]							0.26
Drug vs. Placebo	4	1417	0.31	0.21	0.42	2.61	
Intervention vs. Usual Care	12	5996	0.34	0.20	0.48	33.84***	
Setting							13.34***
Home component	11	2666	0.28	0.19	0.37	24.01**	
Exclusively medical setting	6	4780	0.46	0.37	0.55	2.94	
Delivery[3]							49.77***
Group components	4	4749	0.49	0.34	0.64	6.07	
One-to-one only	12	2606	0.26	0.14	0.38	11.86	
Medication							26.23***
SSM	7	5736	0.42	0.37	0.48	12.83*	
No SSM	10	1710	0.32	0.13	0.50	26.48**	
Outcome							3.58
PP	6	1133	0.29	0.00	0.57	9.11	
CA	11	6313	0.42	0.36	0.48	24.02**	
BM1 'Provide information on the health consequences of smoking and smoking cessation'							1.87
Present	8	6350	0.36	0.21	0.50	27.01***	
Absent	9	1096	0.27	0.11	0.44	7.29	
BM2 'Boost motivation and self-efficacy							7.29**
Present	12	2940	0.30	0.21	0.39	26.43**	
Absent	5	4506	0.43	0.21	0.65	5.54	
BM3 'Provide feedback on current behaviour and progress'							1.06
Present	5	4668	0.35	0.11	0.59	16.26**	
Absent	12	2778	0.30	0.19	0.41	11.91	
BM4 'Provide rewards contingent on successfully stopping smoking'							0.66
Present	3	853	0.38	0.24	0.52	0.37	
Absent	14	6593	0.32	0.19	0.44	41.03***	
BM6 'Prompt commitment from the client there and then'							0.14
Present	3	742	0.36	0.22	0.51	1.49	
Absent	14	6704	0.33	0.21	0.45	39.69***	
BM7 'Provide rewards contingent on effort or							2.03

				95% Confidence Intervals		Homogeneity Analysis	
Measure	*k*	*n*	d_+	*Lower*	*Upper*	*Qw*	*Qb*
progress’							
Present	3	634	0.42	0.05	0.79	7.45*	
Absent	14	6812	0.30	0.20	0.41	31.59**	
BM9 ‘Conduct motivational interviewing’							0.04
Present	4	412	0.34	-0.06	0.74	5.59	
Absent	13	7034	0.36	0.29	0.44	33.89***	
BM10 ‘Identify reasons for wanting and not wanting to stop smoking’							2.78
Present	4	543	0.21	0.04	0.39	1.52	
Absent	13	6903	0.36	0.23	0.48	34.89***	
BS1 ‘Facilitate barrier identification and problem solving’							3.00
Present	7	2177	0.28	0.11	0.46	23.45***	
Absent	10	5269	0.37	0.26	0.48	13.92	
BS2 ‘Facilitate relapse prevention and coping’							0.17
Present	11	6556	0.33	0.23	0.43	34.4***	
Absent	6	890	0.36	0.14	0.59	6.72	
BS3 ‘Facilitate action planning/develop treatment plan’							4.72*
Present	7	5057	0.44	0.39	0.50	11.71	
Absent	10	2389	0.33	0.17	0.50	24.19**	
BS4 ‘Facilitate goal setting’							0.17
Present	10	6552	0.31	0.18	0.44	36.79***	
Absent	7	894	0.34	0.20	0.49	3.59	
BS5 ‘Prompt review of goals’							1.08
Present	4	1028	0.28	0.14	0.43	4.25	
Absent	13	6418	0.35	0.23	0.48	34.17***	
BS6 ‘Prompt self-recording’							4.83*
Present	5	4962	0.40	0.22	0.57	16.10**	
Absent	12	2484	0.29	0.15	0.42	13.86	
BS8 ‘Advise on environmental restructuring’							0.14
Present	3	742	0.36	0.22	0.51	1.49	
Absent	14	6704	0.33	0.21	0.45	39.69***	
BS13 ‘ Advise on methods of weight control’							33.48***
Present	3	4539	0.53	0.37	0.69	4.35	
Absent	14	2907	0.25	0.15	0.36	13.42	
A1 ‘Advise on stop-smoking medication’							0.67
Present	10	6593	0.35	0.23	0.47	29.27***	
Absent	7	853	0.29	0.09	0.49	6.61	
A2 ‘Advise on/facilitate use of social support’							8.00**
Present	7	5372	0.40	0.23	0.57	13.40*	
Absent	10	2074	0.25	0.11	0.39	7.99	
A3 ‘Adopt appropriate local procedures to enable							0.15

				95% Confidence Intervals		Homogeneity Analysis	
Measure	*k*	*n*	*d_+*	*Lower*	*Upper*	*Qw*	*Qb*
clients to obtain free medication’							
Present	7	5256	0.37	0.28	0.45	15.73*	
Absent	10	2190	0.35	0.20	0.51	24.21**	
A4 ‘Ask about experiences of stop smoking medication that the smoker is using’							3.45
Present	3	4608	0.40	0.25	0.56	3.82	
Absent	14	2838	0.31	0.18	0.43	28.12**	
A5 ‘Give options for additional and later support’							0
Present	8	5787	0.36	0.28	0.44	21.82**	
Absent	9	1659	0.36	0.19	0.54	18.98*	
RD1 ‘Tailor interactions appropriately’							3.43
Present	10	6498	0.37	0.20	0.54	31.53***	
Absent	7	948	0.24	0.11	0.37	3.23	
RD2 ‘Emphasise choice’							3.48
Present	6	5445	0.41	0.33	0.48	10.99	
Absent	11	2001	0.31	0.14	0.47	26.23**	
RI1 ‘Assess current and past smoking behaviour’							0.03
Present	11	6114	0.36	0.27	0.45	29.39**	
Absent	6	1332	0.35	0.12	0.57	7.27	
RI2 ‘Assess current readiness and ability to quit’							0.04
Present	8	5300	0.35	0.25	0.45	16.25*	
Absent	9	2146	0.36	0.21	0.51	21.94**	
RI3 ‘Assess past history of quit attempts							1.39
Present	3	774	0.26	0.05	0.48	3.90	
Absent	14	6672	0.35	0.23	0.46	35.83***	
RI5 ‘Assess nicotine dependence’							9.12**
Present	5	1242	0.19	0.07	0.31	4.17	
Absent	12	6204	0.39	0.27	0.51	23.67*	
RI7 ‘Assess attitudes to smoking’							2.50
Present	3	485	0.21	0.03	0.39	1.47	
Absent	14	6961	0.36	0.24	0.47	35.22***	
RI10 ‘Assess physiological and mental functioning’							0.71
Present	4	4274	0.37	-0.04	0.78	11.50**	
Absent	13	3172	0.33	0.26	0.40	23.24*	
RC1 ‘ Build general rapport’							0.17
Present	4	4410	0.32	0.14	0.50	9.15*	
Absent	13	3036	0.34	0.21	0.46	26.83**	
RC4 ‘Explain expectations regarding treatment programme’							2.07
Present	4	4641	0.39	0.26	0.53	5.55	
Absent	13	2805	0.32	0.19	0.44	27.34**	

				95% Confidence Intervals		Homogeneity Analysis	
Measure	*k*	*n*	d_+	*Lower*	*Upper*	*Qw*	*Qb*
RC5 'Offer/direct towards appropriate written materials'							0.28
Present	9	5872	0.41	0.36	0.46	21.77***	
Absent	8	1574	0.38	0.19	0.58	19.58**	
RC6 'Provide information on withdrawal symptoms'							2.41
Present	6	1535	0.39	0.24	0.54	12.75*	
Absent	11	5911	0.30	0.16	0.44	28.78**	
RC8 'Elicit client views'							0.36
Present	5	1042	0.31	0.19	0.43	3.93	
Absent	12	6404	0.35	0.22	0.49	34.87***	
COPD medication advice							0.02
Present	4	247	0.37	-0.03	0.76	5.82	
Absent	13	7199	0.35	0.26	0.43	34.44***	
COPD specific information							1.35
Present	7	1489	0.35	0.11	0.59	23.61***	
Absent	10	5957	0.42	0.37	0.47	16.15	
Link between COPD and smoking							8.42**
Present	4	4524	0.45	0.39	0.51	6.11	
Absent	13	2922	0.31	0.18	0.45	28.92**	
BS 'Specific focus on behaviour, maximising self-regulatory capacity/skills'							1.13
Present	13	7190	0.32	0.23	0.42	38.92***	
Absent	4	256	0.46	0.18	0.75	2.50	
A ' Promote adjuvant activities'							0.89
Present	13	7169	0.33	0.24	0.42	38.72***	
Absent	4	277	0.45	0.14	0.76	2.79	

Note:[1]Defined as power>0.5 and sample size≥35 in each cell (Coyne, Thombs, & Hagedoorn, 2010);[2] One study compared 2 active conditions; [3]*k*=15 Wilson et al., excluded as their experimental groups compared individual and group support *significant at $p<0.05$; **significant at $p<0.01$***significant at $p<0.001$; SSM = Stop Smoking Medication

The finding that *Advise on/ facilitate use of social support* was associated with more effective smoking cessation interventions for people with COPD echoes the results of a previous review concerning smoking cessation in the general population (West, Walia, Hyder, Shahab, & Michie, 2010). However, eight techniques that West et al. found were effective in the general population (and were used in ≥ 3 tests in the present review) were not associated with larger effect sizes here. These findings suggest that although fewer techniques are effective for people with COPD than for members of the general public, social support is an important aid to quitting for all smokers. Such findings also imply that it may be advantageous to tailor smoking cessation efforts to the target sample as it cannot be assumed that BCTs that are effective for members of the general public are similarly effective for specific groups.

Two techniques, *Assess nicotine dependence* and *Boost motivation and self-efficacy*, were contra-indicated among smokers with COPD (meaning the interventions without these techniques, were more effective than those with them). One possible explanation for the negative effect of assessing nicotine dependence is that such assessment could reinforce the idea that the person is 'addicted' to smoking and thus reduce self-efficacy in relation to quitting. Further primary research on how best to feed back nicotine dependence assessments is needed to test this hypothesis. A possible explanation for the second contra-indicated BCT is that smokers with COPD who take part in smoking cessation interventions may already be highly motivated to quit. Additional attempts to boost motivation and self-efficacy could therefore lead to *overmotivation* which is known to hamper effective goal striving and undermine rates of goal attainment (Baumeister, 1984; Heckhausen & Strang, 1988). Consistent with this idea, none of the BCTs that concerned improving motivation (i.e., BM codes in Michie et al.'s, 2011, taxonomy) proved effective. It has previously been reported that smokers with COPD may fall into two motivational categories, namely, those who are unmotivated to quit and would benefit from motivational techniques, and participants who are motivated to quit and would benefit from volitional interventions such as implementation intentions (Hilberink, Jacobs, Schlösser, Grol, & de Vries, 2006). It may be important, therefore, to tailor interventions appropriately. This review suggests that, for smokers with COPD that participated in these interventions, building self-regulation capacity and skills that facilitate the translation of motivation into action may be more important than techniques aimed at merely increasing motivation to quit smoking. The implication is that future studies would do well to measure motivation and self-regulation capacity prior to conducting the intervention so that time and resources can be devoted to the particular issues faced by participants (forming strong intentions to quit and/or the effective implementation of quit intentions).

2.4.1 Limitations and Directions for Future Research

The main limitation of the present review is the paucity of RCTs that were available for analysis (k = 17). The quality of the included studies was variable, with 7 out of 17 falling below the threshold for 'high quality' (van der Meer et al., 2003). Furthermore, only 10 studies reported an *a priori* power calculation, and only 9 studies were adequately powered according to Coyne et al.'s (2010) criteria. Although both the funnel plot and Egger's regression suggest that publication bias does not present a problem for this review, including unpublished or grey literature may have allowed a larger sample of RCTs to be considered. In future the inclusion of high quality grey literature should be considered.

Descriptions of the BCTs used in interventions in the original articles were often brief and, while efforts were made to retrieve further information, the full range of BCTs deployed may not have been captured in all studies. It has been reported recently that fewer than one-half of the BCTs listed in intervention manuals and protocols, are reported in the final publications (Lorencatto, West, Stavri, & Michie, 2012). The introduction of online supplements and requiring submission of the full intervention protocol before publication of RCTs should mean that reports of interventions will improve in future, though Lorencatto et al., (2012) have not found evidence of this improvement thus far. A related difficulty is that there is no way of knowing whether all of the reported BCTs were actually delivered during the intervention. Finally, the large number of moderators considered introduces the potential of some being significant by chance. To address this issue, the higher-level categories within the Michie et al., (2011) taxonomy (motivation, self-regulatory capacity/ skills, adjuvant activities and general aspects of the interaction) were also considered. This approach was taken in a previous review that identified effective approaches to increase exercise related self-efficacy (Ashford, Edmunds, & French, 2010). However, although the majority of interventions in the present review included techniques from all four categories, only two categories reached the necessary $k \geq 3$ tests in both the absence and presence categories. These limitations are inherent to coding BCTs from a small number of published reports. Analysis with a greater number of primary studies, specifically investigating the roles of motivating and self-regulating BCTs for people with COPD, and how these techniques are being delivered would consolidate these initial results and allow for more confidence in designing smoking cessation interventions for this population. Additional RCTs of smoking cessation interventions for people with COPD should be a priority in future research (Parker & Eaton, 2012).

Additional studies are needed to permit more powerful tests of the effectiveness of BCTs and more authoritative analyses of the specific BCTs that engender the greatest cessation rates. As current UK practice is to refer people with COPD to the SSS, any new interventions should be evaluated in relation to the quit rates observed in the SSS. Future studies also need to be adequately powered, and whenever possible should adopt the “Russell Standard” for the measurement of smoking cessation (6- or 12-month biochemically-validated abstinence; West, Hajek, Stead, & Stapleton, 2005). Finally, reports of RCTs should follow the CONSORT recommendation (Schulz, Altman, & Moher, 2010) that all intervention procedures are described ‘with sufficient details to allow replication’ (p. 699) to facilitate cumulative knowledge concerning the effectiveness of BCTs.

2.4.2 Conclusions

This chapter describes a meta-analysis that aimed to identify the most effective behaviour change techniques used in smoking cessation interventions for people with COPD. Seventeen RCTs were identified, and a mean quit rate of 13.19% and a sample-weighted average effect size of 0.33 were observed. Two BCTs were contra-indicated and five BCTs were associated with improved effectiveness. The present findings suggest boosting motivation and assessing nicotine dependence may be counterproductive whereas facilitating action planning, prompting self-recording, offering advice on weight control and the use of support, and linking COPD and smoking should each prove helpful in future smoking cessation interventions for people with COPD. This review has identified that the BCTs identified as effective for the general population of smokers, may not be the most appropriate for people with COPD, and that tailoring smoking cessation support to focus on self-regulation rather than motivation might make the NHS Stop Smoking Service (SSS) more effective for people with COPD. Further research, including studies investigating interventions tailored according to an individual's initial motivation and self-regulatory capacity, are needed to corroborate the findings obtained here. More and better quality studies will help to identify the most effective BCTs and so ensure that smoking cessation interventions for people with COPD are as effective as possible.

In terms of developing a persuasive technology intervention, the NHS SSS already utilises aspects of persuasive technology such as mobile phone app and text message based services, and PwCOPD should already be being encouraged to contact this service at all opportunities. It is therefore recommended that future research investigates the outcomes if these apps are tailored for people with COPD with the addition of further BCTs focussed on self-regulation. This tailoring would be more efficiently done from within the NHS SSS (or with access to the NHS SSS app code), as these apps are already available. For the current project it was felt that to design a persuasive technology intervention aimed at smoking cessation from scratch, with the limited budget and time available would fall short of the already available service. It was therefore decided it would be preferable to focus on an area where there was not an existing persuasive technology intervention for PwCOPD recommended by the NHS.

3 Study 2: Effective Behaviour Change Techniques in Physical Activity Interventions for People with Chronic Obstructive Pulmonary Disease (PwCOPD): A Meta-Analysis with Meta-Regression

3.1 Introduction

PwCOPD have been found to lead more sedentary lives than healthy comparators; which can have a negative impact on social activities, satisfaction and quality of life (Steele et al., 2008). Reducing physical activity[4] can result in muscle weakening and greater dyspnoea (shortness of breath). Dyspnoea can be unpleasant and provoke anxiety (Cambach, Wagenaar, Koelman, van Keimpema, & Kemper, 1999) leading to further activity reduction and a negative cycle of inactivity (Bourbeau, 2009a). As well as COPD affecting a person's ability to be active, it is thought that COPD also effects exercise capacity (defined as 'the maximum amount of physical exertion that a patient can sustain' (Goldstein, 1990, p.69). The mechanism by which COPD affects exercise capacity is unclear (Troosters, Casaburi, Gosselink, & Decramer, 2005), however muscle dysfunction is known to occur, potentially as a consequence of systemic inflammation (Agusti, 2007). This dysfunction is characterised by muscle loss and muscle weakness and can have a negative effect on exercise capacity and activities of daily living, such as shopping, washing, cleaning etc. (Agusti, 2007; Troosters et al., 2005). Composite measures of symptoms such as the BODE (Body mass index, Obstruction, Dyspnoea and Exercise) index (Celli et al., 2004), which incorporate measures of exercise capacity, dyspnoea and weight alongside lung functioning, have been found to be better predictors of mortality than lung functioning alone (Celli et al., 2004). While the decline in lung functioning caused by COPD cannot be reversed, improving other aspects of functioning, such as exercise capacity, can still have important benefits (Agusti, 2007).

[4] The definitions of physical activity and exercise used are as follows: Physical activity is defined as 'any bodily movement produced by skeletal muscles that results in energy expenditure' and exercise as 'a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness' (Caspersen, Powell, & Christenson, 1985, p. 126). Increasing both physical activity and exercise are correlated with improvements in physical fitness (Caspersen et al., 1985). For this review the term physical activity will be used as the more general term, however if papers refer specifically to exercise, this will be reported as such.

3.1.1 Current Treatments

The current guidelines for COPD care strongly endorse multi-component care that addresses the widespread and varied symptoms that result from COPD (National Clinical Guideline Centre, 2010). One of the targets of COPD care is to increase physical activity through pulmonary rehabilitation (PR). PR is a tailored flexible approach that can incorporate many different components dependent on individual needs and local resources. There are high quality reviews comparing PR with usual care (Lacasse et al., 2002) and the efficacy of different components of PR (Lacasse, Guyatt, & Goldstein, 1997; Troosters et al., 2005). In brief, it is now accepted that PR has a positive effect on Health Related Quality of Life (HRQoL) and exercise capacity and is beneficial to PwCOPD (Lacasse et al., 1997; National Institute of Health and Clinical Excellence, 2010a; Ries et al., 2007; Troosters et al., 2005). Although the effects of PR on exercise capacity did not reach the threshold for clinical significance in the most recent Cochrane review, they have repeatedly reached statistical significance and it was concluded in 2002 that the benefits of PR compared to usual care required no further research (Lacasse et al., 2002). PR is now included in the clinical guidelines for COPD in the UK, Europe and the USA (National Clinical Guideline Centre, 2010; Nici et al., 2006; Ries et al., 2007). The current NICE guidelines recommend 'a minimum of 6 weeks and a maximum of 12 weeks of physical exercise, disease education, psychological and social interventions' (National Clinical Guideline Centre, 2010, p. 266) with best practice recommending a minimum of two supervised sessions per week, and two home based sessions per week (NHS Medical Directorate, 2012). The aim is to improve functioning both physically and socially, enabling independent, effective and continuing self-management of COPD (National Clinical Guideline Centre, 2010; Ries et al., 2007).

However, while the evidence shows that activity undertaken as part of PR increases exercise capacity and HRQoL, many studies of PR do not look at changes in behaviour following PR. Improvements in exercise capacity enable people with COPD to engage in exercise and physical activity, but they do not necessarily mean that they will. To achieve long-term gains, PwCOPD would need to continue leading an active lifestyle post-PR. Recent studies have suggested either that there is wide variability in activity levels post PR (Dyer et al., 2013) or that participating in PR does not improve daily activity levels (Egan et al., 2012). This could indicate that even those who engage in PR, do not make the necessary changes to their lifestyle that would enable them to maintain the benefits achieved.

3.1.2 Rationale for the present review

The purpose of the present review is to identify studies that focus on activity outside of structured PR classes, identify how effective they are, identify the BCTs used, and finally, which BCTs are associated with the largest effects on physical activity. The interventions were coded according to the generic taxonomy of BCTs described in Section 1.1.4 (Abraham & Michie, 2008). Although generic in nature, during development this taxonomy was evaluated by coding interventions that aimed to increase physical activity as well as those aimed at encouraging healthy eating (Abraham & Michie, 2008). In Chapter 2 the smoking specific BCT taxonomy is described. This taxonomy was organised according to the function the BCTs perform e.g. *addressing motivation* or *maximising self-regualtory capacity/ skills* (Michie, Ashford, et al., 2011; Michie, Hyder, et al., 2011). In contrast the BCTs in the generic taxonomy are numbered, rather than organised according to a hierarchical structure. However theories that are associated with most of the BCTs are identified; for example the BCT *Prompt self-monitoring of behavior* is associated with control theory (Abraham & Michie, 2008). This allows researchers to group the BCTs according to their associated theories, but also identify where theories overlap, for example *provide information on consequences* is associated with four separate theories (the Theory of Reasoned Action/Planned Behaviour, social cognitive theory and the information-motivation-behavioural skills model; Abraham & Michie, 2008).

3.2 Method

3.2.1 Inclusion and Exclusion criteria

The search strategy used is fully described in Table 2.1 in Chapter 2; to recap, it briefly comprised of COPD terms AND intervention/behaviour terms AND smoking terms OR exercise terms OR breathing training terms. The same databases were searched in this review as in the review reported in Chapter 2 (CINAHL, MEDLINE, PsycINFO, Web of Knowledge (all databases) and EMBASE), and papers cited by and citing included studies were also assessed. In addition, to identify grey literature, the term COPD was used to search the OpenGrey database, publications from the Department of Health, and registered behavioural intervention studies on clinicaltrials.gov. The authors of potentially eligible trials that had been completed (i.e. not listed as currently recruiting, active but not recruiting, or unknown) were contacted if their contact details could be found. The search was last updated 04/11/13.

Studies were included if (a) they described a randomised controlled trial (RCT) of an intervention that aimed to alter participants' self-directed physical activity (self-directed activity refers to activity that is undertaken unsupervised, so studies needed to include planned unsupervised exercise sessions, not only general encouragement to do more), (b) participants had a diagnosis of COPD and (c) a measure of physical activity was reported following the intervention. Papers were excluded if they a) reported a formal pulmonary rehabilitation program, defined as two or more supervised exercise sessions per week throughout the intervention (b) were review papers or, (c) were not written in English. Authors were emailed where insufficient information was reported in the paper to be able to compute an effect size (e.g., relevant data was represented in graph form only).

3.2.2 Outcome definitions

The outcome of interest in this review was physical activity; levels of physical activity, functional exercise capacity, and limb strength were extracted as changes in these could indicate the amount of physical activity undertaken during the intervention.

3.2.3 Quality assessment

The methodological quality of the primary studies was assessed using the Delphi list (Verhagen et al., 1998; see Appendix I: Table 2).

3.2.4 Coding of Behaviour Change Techniques

The BCTs used in each of the reviewed interventions were coded according to Abraham and Michie's taxonomy by the thesis author. In addition, a random sample of ten interventions were cross-coded by an independent coder who had used the taxonomy previously. Initial agreement between the coders was 82%, with a Kappa coefficient of 0.38, which represents "fair agreement" (Landis & Koch, 1977). Disagreements were resolved by discussion. In concordance with the coding manual, BCT6 'Provide general encouragement' was not coded as Abraham and Michie did not find it to be reliable (Abraham & Michie, 2008). The two BCTs identified in the smoking review as specific to COPD were also coded; *COPD-specific information* where information about areas of COPD management in addition to physical activity is given (e.g., smoking cessation advice) and *COPD medication advice* for the optimisation of COPD medication as part of the intervention.

3.2.5 Meta-Analytic Strategy

Effect sizes with associated standard errors were calculated for all between group comparisons for each study (*d)*. Where studies reported multiple eligible outcomes, an effect size was calculated for each. Where papers reported multiple measures of the same outcome (e.g. several measures of functional exercise capacity) or outcomes over more than one time point, a pooled effect size was calculated (Michie, Abraham, et al., 2009). An overall pooled effect size, across outcome measures, was also calculated for each study.[5]

The impact of ten moderators was examined: (i) nature of the control group (coded as exercise if the control group contained any exercise or physical activity component or no exercise, if the control group contained no exercise or physical activity component), (ii) the number of supervised sessions delivered iii) the number of unsupervised sessions recommended (iv) how supervised and unsupervised components were delivered (concurrent, consecutive or initial instruction or demonstration only), (v) study quality, (vi) level of attrition (operationalized as the percentage of participants who dropped out between randomisation and final follow-up), (vii) statistical power (calculated post-hoc using *d*, the overall sample size and a probability level of 0.05, coded as ≥0.55 or < 0.55 as power of 0.55 or above has been reported as acceptable (Coyne et al., 2010) (viii) duration of the intervention (operationalized as the time interval (in weeks) from randomisation to final follow-up), (ix) the behaviour change techniques used (coded as present or absent) and (x) the number of behaviour change techniques used.

Potential moderators of the effect of interventions on outcomes were investigated using univariate meta-regression when ≥3 cases were available for each level (e.g., present vs. absent). Meta-regression is described as ‘an extension to traditional meta-analysis’ (Harbord & Higgins, 2008, p.493) in which studies are grouped according to a moderator (for example, a BCT), and the difference in effect size between groups of studies is assessed using a measure of homogeneity. For example, in the review of the effectiveness of interventions targeting smoking cessation reported in Chapter 2, the homogeneity statistic *Q* was used to evaluate moderators of the effect of interventions on smoking. The advantage of extending the meta-analysis using meta-regression is that it takes account of the heterogeneity of effect sizes across the sample of studies and assesses what proportion of this heterogeneity can be assigned to a particular moderator (Harbord & Higgins, 2008; Thompson & Higgins, 2002).

[5] The Q_b statistic was used in sensitivity analysis to compare effects sizes derived from pooled and outcome measure specifics using META 5.3 (Schwarzer, 1987). There was no significant difference between the effect size calculated using only exercise capacity outcomes (Qb = 0.93, p = 0.76), and the effect size calculated using only timed walk tests (Qb = 0.01, p = 0.92) so the pooled effect sizes were used for the remaining analyses.

Meta-regression also allows for both continuous and discrete moderators to be considered (Patall & Cooper, 2008; Thompson & Higgins, 2002).

Considering continuous and discrete moderators together also allows a different approach to be taken to one of the limitations identified in the review of smoking cessation interventions (see Chapter 2). Meta-analyses of studies which focus on behaviour change often rely on a relatively small number of studies, and a relatively large number of potential moderators. This situation could increase the likelihood of making a Type I error when investigating potential moderators (i.e., falsely rejecting the null hypothesis). One approach would be to use the Bonferroni correction, which involves dividing the *p* value by the number of comparisons made. However, in meta-analysis, this correction is overly conservative and could increase the risk of Type II errors, especially if the moderators may be correlated (Higgins & Thompson, 2004). Meta-regression offers a more flexible approach to this limitation by allowing a specified number of permutations (in this case, 20,000) based on the Monte Carlo simulation to calculate the 'true' *p* value for the amount of variance explained by any one moderator (if univariate), or group of moderators (if multivariate; Harbord & Higgins, 2008). In short, although homogeneity *Q* was used to evaluate the effect of moderators in the review of intervention effects on smoking reported in Chapter 2, meta-regression is probably a more conservative technique for investigating multiple moderators. As the smoking review had already been published, the analyses reported there were not revised, but the current review used meta-regression to evaluate the effect of moderators.

Between-study heterogeneity within each level of moderator (I^2), the change in effect size due to moderator (regression coefficient β) and the proportion of variance explained by each moderator (adjusted R^2) were calculated using the revised `metareg` (with permute option) and `metan` command in STATA 12 (StataCorp, 2011). For dichotomous moderator variables (coded as present = 1 and absent = 0), a negative β coefficient describes a contra-indicated moderator, i.e., interventions without these moderators are more effective than those with them (Michie, Whittington, et al., 2012). The adjusted R^2 value describes the difference between the regression model with the identified moderator as a covariate, and the regression model with no covariates. If the former is smaller than the latter (i.e., the identified moderator explains less of the variance than chance), this figure can be negative (Harbord & Higgins, 2008), any negative R^2 will be truncated to zero (Michie, Whittington, et al., 2012). Multivariate meta-regression was used for groups of moderators associated with psychological theories (as identified by (Abraham & Michie, 2008), and for moderators with a $\beta > 0.1$ in a positive or negative direction as in (Michie, Abraham, et al., 2009). Publication bias was assessed using the `metabias` command.

3.3 Results

3.3.1 Studies included in the review

6741 papers were initially identified (following duplicate removal, see Figure 3.1 for study flow through the review). A total of 28 studies were identified with a total sample size of 1286 (see Appendix I: Table 5 for study characteristics). Individual study sample sizes were small from 10 to 130 (*mean* = 40.79, *SD* = 28.15). Mean age ranged from 56 to 72 years old, average FEV_1 ranged from 67% to 27% of predicted values indicating a range from moderate to very severe COPD (GOLD, 2011), see Appendix I: Table 6. The control groups were varied, with 12 studies including physical activity as part of their control condition. Interventions included both supervised and unsupervised exercise sessions; unsupervised sessions could be undertaken concurrently alongside the supervised sessions (*k* = 14); consecutively, following the supervised sessions (*k* = 6), or following a single supervised session, or brief instructions (*k* = 8). Participants were advised to continue with the unsupervised exercise until the final measurement point; this length of time varied from four weeks to two years, with a median of 14 weeks. The number of supervised and unsupervised sessions also varied between the primary studies; the number of supervised sessions ranged from 1 to 108 (*median* = 12.00) and the number of unsupervised sessions ranged from 24 to 674 (*median* = 107.50). The type of exercise or activities undertaken included breathing training, aerobic exercises, strengthening exercises (or a combination of these), yoga, or tai chi (See Appendix I: Table 5). The outcomes of interest were activity performance, functional exercise capacity and strength. Only two studies used exercise performance as an outcome measure. The majority of studies reported a walking test of functional capacity, either 6 or 12 minute walk tests (*k* = 19), the endurance shuttle walk test (*k* = 4), or the incremental shuttle walk test (*k* = 4). Outcomes related to limb strength were reported in 5 studies.

Of the 27 BCTs coded (25 from the original taxonomy, 2 specific to COPD), 21 were used in one or more interventions and 16 were used in 3 or more studies (see Appendix I: Table 5). The mean number of BCTs used in the interventions was 3.43 (*SD* = 2.86). Six interventions did not use any behaviour change techniques in the experimental group that were not used in the control group. The most commonly used BCTs were *provide instruction* (*k* = 14), *prompt self-monitoring of behaviour* (*k* = 11) and *prompt specific goal setting* (*k* = 9).

3.3.2 Quality Assessment

The average quality rating was 5.11 (*SD* = 1.37) and 54% of the studies (*k* = 15) reached the ≥ 5 threshold for high quality (van der Meer et al., 2003). Very few studies reported an *a priori* calculation of the sample size necessary for the study to be adequately powered (*k* = 6). Of those that did, only two achieved the proposed sample size at the final follow-up measure. Post-hoc power was calculated as in Chaper 2 (see notes for Table 2.3); the range was from 3% to 100% with an average of 40% (*SD* = 0.35). Coyne et al. propose an adequate quality threshold of 55% power and a sample size of ≥ 35 per cell (Coyne et al., 2010). While 29% of studies (*k* = 8) reached the 55% threshold of adequate power, only one of these also had the recommended sample size. Percentage attrition from randomisation to the longest follow-up ranged from 0 to 62.39%, with an average of 24.90% (*SD* = 16.08%;see Table 3.1). Although the studies were conducted satisfactorily according to the Delphi score, and no excluions were made on the basis of quality, the number of underpowered studies with small sample sizes and high attrition rates should be taken into account when interpreting the results of this meta-analysis.

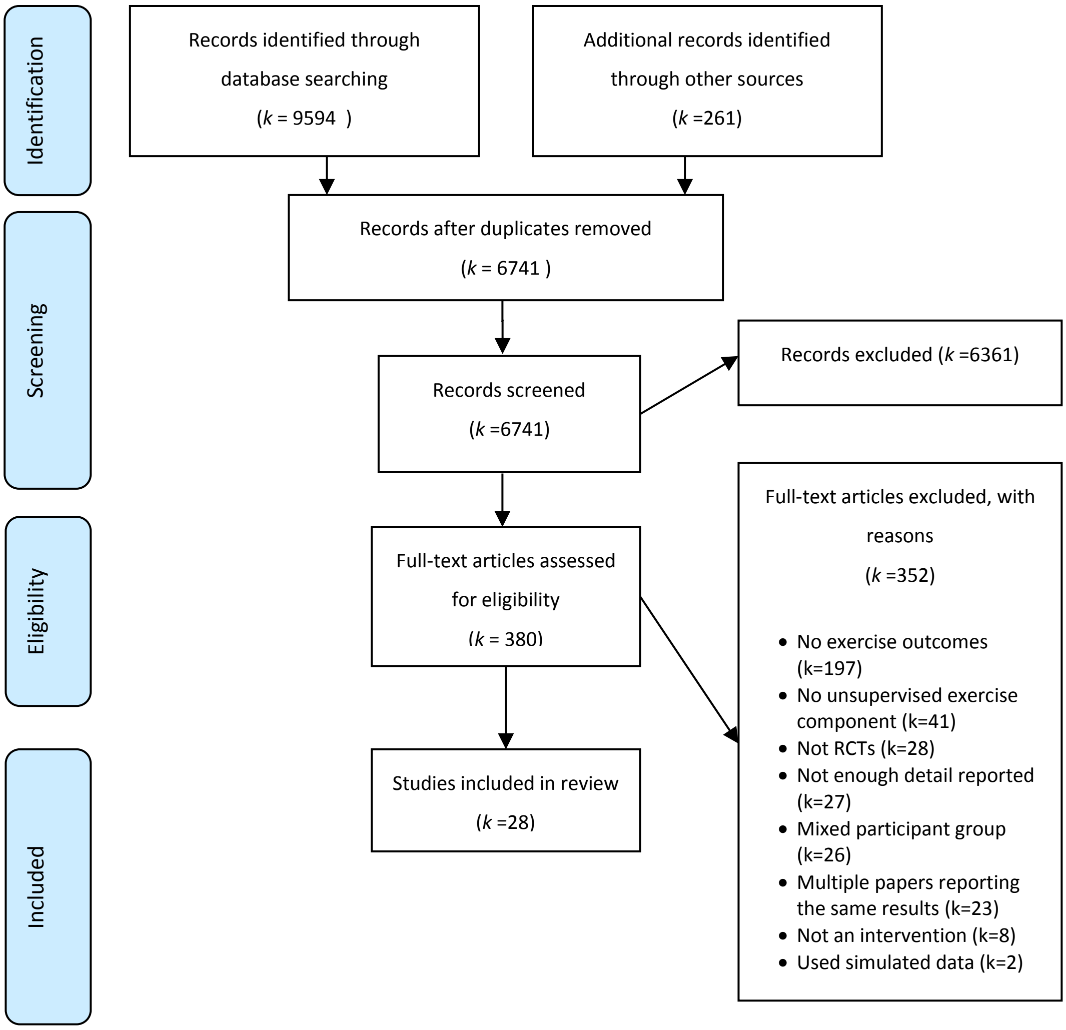

Figure 3.1: Flow of Articles through the Phases of the Present Review

Table 3.1: Intervention Outcomes

Authors	*Ne*	*Nc*	*Quality*	*A priori sample size*	*Post-hoc power*	*% attrition*	*Effect size (d)*			
							Performance	*Capacity*	*Strength*	*Pooled*
Bauldoff, Hoffman, Sciurba, & Zullo, 1996	11	11	5	NR	0.34	0	-	-	0.55	0.55
Bauldoff, Hoffman, Zullo, & Sciurba, 2002	12	12	4	18	1.00	NR	-	1.98	-	1.98
Beckerman, Magadle, Weiner, & Weiner, 2005	21	21	7	NR	0.27	26.19	-	0.32	-	0.32
Behnke et al., 2000	15	15	4	NR	1.00	34.78	-	2.11	-	2.11
Berry et al., 2010	61	69	5	170	0.25	25.00	-	-0.27	-0.06	-0.17
Bestall et al., 2003	23	21	5	NR	0.57	21.42	-	0.56	-	0.56
Bjornshave & Korsgaard, 2005	9	11	4	NR	1.00	35.00	-	2.04	-	2.04
Breyer et al., 2010	30	30	4	NR	0.59	7.96	-	0.49	-	0.49
Brooks, Krip, Mangovski-Alzamora, & Goldstein, 2002	21	18	7	NR	0.07	62.39	-	0.06	-	0.06
Carrieri-Kohlman, Gormley, Douglas, Paul, & Stulbarg, 1996	24	26	4	NR	0.06	13.79	-	0.02	-	0.02
Donesky-Cuenco, Nguyen, Paul, & Carrieri-Kohlman, 2009	14	15	5	NR	0.10	29.27	-	0.28	0.02	0.15
du Moulin, Taube, Wegscheider, Behnke, & van den Bussche, 2009	6	6	7	NR	0.26	40.00	-	0.62	-	0.62
Faulkner et al., 2010	6	8	4	100	0.2	30.00	-0.45	-	-	-0.45
Finnerty, Keeping, Bullough, & Jones, 2001	22	23	6	NR	0.55	55.00	-	0.54	-	0.54
Ghanem, Elaal, Mehany, & Tolba, 2010	24	14	5	NR	1.00	0	-	3.27	-	3.27
Güell et al., 2000	23	20	4	NR	1.00	21.67	-	1.74	-	1.74
Hernández et al., 2000	20	17	4	NR	0.68	38.33	-	0.72	-	0.72
Hospes, Bossenbroek, Ten Hacken, van Hengel, & de Greef, 2009	18	17	4	NR	0.31	10.26	0.59	0.22	0.40	0.40
McGavin, Gupta, Lloyd, & McHardy, 1977	12	12	4	NR	0.21	14.29	-	0.36	-	0.36
Nguyen et al., 2008	19	20	7	NR	0.09	24.00	-	0.25	-0.04	0.10
O'Shea, Taylor, & Paratz, 2007	27	27	7	45[a]	0.06	24.07	-	-0.03[a]	0.06	0.02
Oh, 2003	15	8	4	NR	0.77	32.33	-	1.05	-	1.05
Riera et al., 2001	10	10	8	NR	0.82	0	-	1.19	-	1.19

Authors	*Ne*	*Nc*	*Quality*	*A priori sample size*	*Post-hoc power*	*% attrition*	*Effect size (d)*			
							Performance	*Capacity*	*Strength*	*Pooled*
Ries & Moser, 1986	5	6	4	NR	0.11	29.49	-	0.30	-	0.3
Ringbaek, Brondum, Martinez, Thogersen, & Lange, 2010	55	41	3	NR	0.07	28.13	-	0.04	-	0.04
Spencer, Alison, & McKeough, 2010	24	24	5	58	0.20	18.64	-	0.24	-	0.24
Waterhouse, Walters, Oluboyede, & Lawson, 2010	50	53	7	140	0.29	50.31	-	0.22	-	0.22
Yeh et al., 2010	5	5	6	NR	0.05	0	-	0	-	0

Ne: Number of participants in the experimental group; *Nc*: Number of participants in the control group; NR: Not Reported [a] Authors aimed to recruit 56 to allow for 20% attrition

3.3.3 Effectiveness of Physical Activity Interventions

Using a pooled effect size for each study, the sample-weighted average effect size (d_+) was 0.60 (95% C.I. 0.34-0.85). This means that interventions had a medium-to-large sized effect on physical activity levels among people with COPD, according to Cohen's (1992) criteria (Cohen, 1988). The I^2 statistic was 75.3% indicating high heterogeneity within the sample (Higgins, Thompson, Deeks, & Altman, 2003).

Significant small study effects were found (Egger's test p <0.01), meaning that smaller studies are significantly associated with larger effect sizes in this analysis. This finding could indicate publication bias, or something about the small studies that made them more effective (Borenstein, 2005). In accordance with Borenstein's (2005) recommendations the 'trim and fill' method was used (Duval & Tweedie, 2000) to impute any theoretically missing studies and re-calculate the pooled effect size. This analysis was conducted using the `metatrim` command, and a random effects model. No data was trimmed or filled (see Figure 3.2, trimmed points would be shown with a cross over them, and filled points with a square box around them) indicating that the outliers are not outside what would be expected using a random effects model.

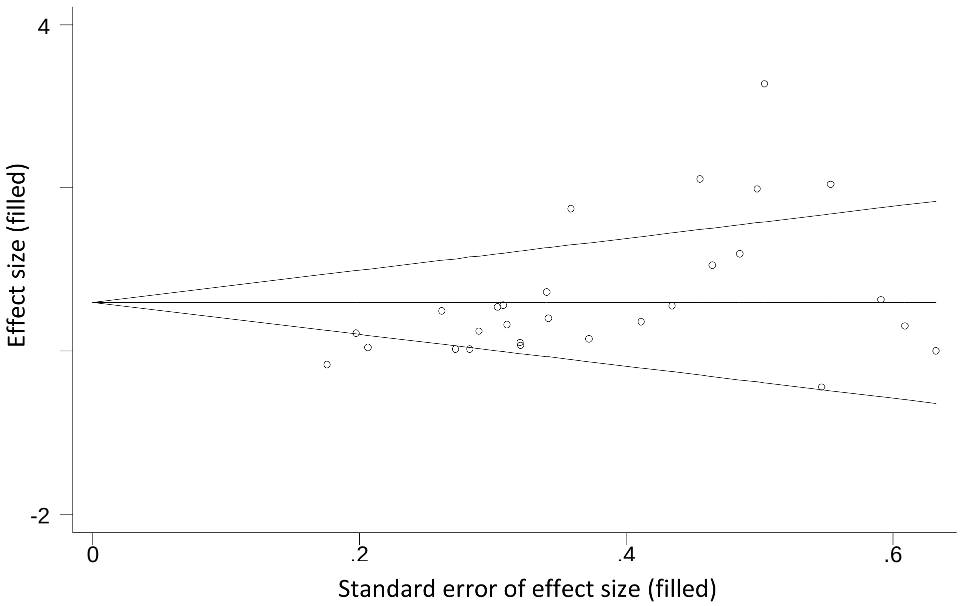

Figure 3.2: Funnel plot showing outcome of trim and fill procedure effect size and standard error (se of theta), no changes to the original funnel plot

Moderating variables – Univariate meta-regression

To investigate the heterogeneity of effect sizes across the primary studies, univariate meta-regression analysis was used to evaluate the impact of 16 BCTs and 10 other intervention characteristics on effect sizes. The majority of the univariate meta-regressions did not explain the heterogeneity of effect sizes (adjusted R^2 in 17 out of the 26 meta-regressions was 0%), see Table 3.2. The greatest amount of variance was explained by post-hoc power (β = 1.03, 95% C.I. = 0.57 – 1.50, p<0.01, Adjusted R^2 = 63.03%), interventions with post-hoc power of 0.55 or above were associated with significantly larger effect sizes (*d* = 1.25, 95% C.I. = 0.78 – 1.73) than those with post-hoc power of <0.55 (*d* = 0.11, 95% C.I. -0.04 – 0.25).

Whether physical activity formed part of the control group explained 7.17% of the overall heterogeneity (β = -0.38, 95% C.I. -1.01 – 0.24, *p* = 0.16). Studies that did not have a physical activity component in the control group tended to find a larger effect size (d_+ = 0.78, 95% C.I. 0.40 – 1.16) than those that did (d_+ = 0.33, 95% C.I. 0.04 – 0.61). Although the number of supervised or unsupervised sessions did not explain any of the variance, the order of these sessions did. Interventions that delivered unsupervised and supervised sessions concurrently tended to report larger effects (d_+ = 1.13, 95% C.I. 0.04 – 0.61), than interventions that delivered initial training or instruction only (d_+ = 0.79, 95% C.I. 0.34 – 1.21) that, in turn, reported larger effects than interventions that delivered all of the supervised sessions first, followed by all of the unsupervised sessions (d_+ = 0.32, 95% C.I. 0.09 – 0.55). The order that the sessions were delivered in explained 5.62% of the heterogeneity of the overall sample of studies.

Five of the BCTs explained some of the heterogeneity in effect sizes from the primary studies. Three of these; *Prompt intention formation* (β = -0.56, 95% C.I. -1.38 – 0.25, p=0.17, Adjusted R^2 = 1.70%), *Prompt barrier identification* (β = -0.51, 95% C.I. -1.30 – 0.28, p=0.16, Adjusted R^2 = 3.98%) and *Prompt practice* (β = -0.72, 95% C.I. -1.53 – 0.10, p=0.06, Adjusted R^2 = 13.12%) had negative β coefficients indicating larger effect sizes when they were absent than when they were present. *Provide instruction* (β = 0.44, 95% C.I. -0.17 – 1.06, p=0.11, Adjusted R^2 = 9.45%) and *COPD specific information* (β = 1.37, 95% C.I. 0.66 – 2.09, p<0.01, Adjusted R^2 = 53.47%) both had positive coefficients indicating more effective interventions if present than absent.

Moderating variables – Multivariate meta-regression models

Multivariate meta-regression models were built for dichotomous moderators with β coefficients >0.1 (See Table 3.3). One model was built with moderators with negative β coefficients (Model 1: BCTs 4, 5, 9, 11, 12, 13, 17, 18, 19 and 20) and one for those with positive *β* coefficients (Model 2: BCTs 8, 10 and COPD specific information). Models based on behaviour change techniques grouped by associated theory were also built; some of the theories only had one behaviour change technique that was used in ≥ 3 studies associated with it (e.g., the Theory of Planned Behaviour). Multivariate models were built for BCTs recommended by control theory (Model 3: BCTs 4, 10, 11, 12 and 13) and by social-cognitive theory (Model 4: BCTs 4, 5, 7, 8 and 9). Model 1 did not predict any of the variance in effect sizes. Model 2 predicted 45.55% of the variance; this is lower than COPD specific information alone although there was a reduction in I^2 to 64.1%; no new significant predictors were identified. Techniques associated with control theory predicted 0.53% of the variance in effect sizes and techniques associated with social cognitive theory predicted 22.90% of the variance in effect sizes (the latter model reduced the heterogeneity slightly compared to the whole sample to 69.69%). However in both of the theory-based multivariate models, the majority of the techniques identified were counter-indicated i.e. their absence was associated with higher effect sizes than their presence; only three of the BCTs were associated with more effective interventions when present than when absent: *Prompt specific goal setting*, *Provide feedback on performance* and *Provide instruction.* No new significant predictors of effect size were identified in the multivariate meta-regression analysis. The *β* coefficient for *Provide feedback on performance* (BCT13) changed from negative to positive in both model 1 and 3, and the same happened to *Plan social support/ change* changes (BCT20) in model 1. This suggests that unmeasured correlations with other BCTs within these models could be responsible for the negative effect seen in the univariate analysis.

Table 3.2: Meta-analysis and univariate meta-regression

					95% C.I.				95% C.I.			
		k	*n*	*d*	*Lower*	*Upper*	I^{2a}	*β*	*Lower*	*Upper*	P^b	*Adjusted* R^2
All		28	1142	0.60	0.34	0.85	75.3	-	-	-	-	-
Control group exercise	Yes	12	614	0.33	0.04	0.61	63.5	-0.38	-1.01	0.24	0.16	7.17%
	No	16	528	0.78	0.40	1.16	75.9					
Power	≥0.55	12	413	1.25	0.78	1.73	78.8	1.03	0.57	1.50	0.00**	63.03%
	<0.55	16	729	0.11	-0.04	0.25	0.0					
Attrition		27	1118	-	-	-	-	-0.01	-0.28	0.01	0.36	0%
Delphi quality		28	1142	-	-	-	-	-0.11	-0.35	0.12	0.31	0%
Duration		27	1122	-	-	-	-	-0.04	-0.02	0.01	0.51	0%
Number of BCTs		28	1142	-	-	-	-	-0.04	-0.15	0.07	0.48	0%
Number of sessions	Supervised	28	1142	-	-	-	-	0.00	-0.01	0.01	0.97	0%
	Unsupervised	24	943	-	-	-	-	-0.00	-0.00	0.00	0.75	0%
Order of supervised and unsupervised sessions	1:Training only	8	262	0.79	0.34	1.21	62.3	-0.28	-0.63	0.07	0.11	5.62%
	2:Consecutive	6	280	1.13	0.11	2.14	91.9					
	3:Concurrent	14	600	0.32	0.09	0.55	44.6					
BCT4: Prompt intention formation	Present	5	154	0.21	-0.11	0.53	0.0	-0.56	-1.38	0.25	0.17	1.70%
	Absent	23	988	0.68	0.38	0.97	78.9					
BCT5: Prompt barrier	Present	5	308	0.16	-0.24	0.56	58.5	-0.51	-1.30	0.28	0.16	3.98%
	Absent	23	834	0.70	0.40	1.00	75.0					

					95% C.I.				95% C.I.			
		k	*n*	*d*	*Lower*	*Upper*	I^{2a}	*β*	*Lower*	*Upper*	P^{b}	*Adjusted* R^2
identification												
BCT7: Set graded tasks	Present	7	224	0.57	0.06	1.08	69.3	-0.06	-0.81	0.68	0.91	0%
	Absent	21	918	0.61	0.31	0.90	77.4					
BCT8: Provide instruction	Present	14	433	0.84	0.40	1.29	78.5	0.44	-0.17	1.06	0.11	9.45%
	Absent	14	709	0.60	0.34	0.85	61.0					
BCT9: Model/ Demonstrate the behaviour	Present	4	149	0.23	-0.09	0.55	0.0	-0.50	-1.39	0.40	0.26	0%
	Absent	24	993	0.68	0.38	0.97	78.4					
BCT10: Prompt specific goal setting	Present	9	388	0.75	0.21	0. 30	82.7	0.20	-0.48	0.88	0.56	0%
	Absent	19	754	0.53	0.24	0.82	71.4					
BCT11: Prompt review of behavioural goals	Present	5	315	0.24	-0.11	0.59	49.8	-0.35	-1.15	0.45	0.35	0%
	Absent	23	827	0.67	0.37	0.98	76.6					
BCT12: Prompt self-monitoring of behaviour	Present	11	395	0.44	0.05	0.84	67.5	-0.25	-0.90	0.41	0.45	0%
	Absent	17	747	0.69	0.35	1.03	78.9					
BCT13: Provide feedback on performance	Present	3	105	0.44	-0.17	1.04	54.3	-0.14	-1.17	0.89	0.80	0%
	Absent	25	1037	0.62	0.34	0.90	77.1					
BCT17: Prompt practice	Present	4	248	-0.06	-0.31	0.19	0.0	-0.72	-1.53	0.10	0.06	13.12%
	Absent	24	894	0.72	0.43	1.00	74.9					
BCT18: Use of	Present	3	236	0.24	-0.08	0.57	31.5	-0.35	-1.31	1.62	0.47	0%

					95% C.I.				95% C.I.			
		k	*n*	*d*	*Lower*	*Upper*	I^{2a}	*β*	*Lower*	*Upper*	P^b	*Adjusted* R^2
follow-up prompts	Absent	25	906	0.65	0.35	0.95	77.0					
BCT19: Provide opportunities for social comparison	Present	3	187	0.39	-0.95	1.73	91.7	-0.24	-1.26	0.78	0.67	0%
	Absent	25	955	0.61	0.36	0.87	70.8					
BCT20: Plan social support/ change	Present	4	232	0.43	-0.47	1.33	88.2	-0.21	-1.11	0.70	0.66	0%
	Absent	24	910	0.62	0.35	0.89	71.9					
BCT24: Stress management	Present	5	171	0.69	0.02	1.36	75.2	0.09	-0.75	0.94	0.78	0%
	Absent	23	971	0.58	0.30	0.86	75.8					
BCT26: Time management	Present	3	195	0.72	-0.46	1.90	91.0	0.06	-0.94	1.07	0.94	0%
	Absent	25	947	0.59	0.33	0.85	71.6					
COPDspec	Present	4	156	1.87	0.76	2.98	87.8	1.37	0.66	2.09	0.00**	53.47%
	Absent	24	986	0.36	0.17	0.55	48.5					

[a] I^2 reported to 1 d.p. as STATA 12 reports to 1 d.p. for meta-analysis; [b] 20000 permutations based on the Monte Carlo simulation; ** Significant at ≤0.01

Table 3.3: Multivariate meta-regressions

		95% C.I.				
	β	*Lower*	*Upper*	p^a	I^2	*Adjusted R^2*
Model 1					75.00%	0%
BCT4: Prompt intention formation	-0.76	-2.22	0.71	0.90		
BCT5: Prompt barrier identification	-0.35	-1.57	0.87	1.0		
BCT9: Model/ Demonstrate the behaviour	-0.23	-1.53	1.06	1.0		
BCT11: Prompt review of behavioural goals	-0.10	-1.06	0.87	1.0		
BCT12: Prompt self-monitoring of behaviour	-0.44	-1.27	0.38	0.89		
BCT13: Provide feedback on performance	0.62	-0.86	2.09	0.96		
BCT17: Prompt practice	-0.81	-1.95	0.33	0.66		
BCT18: Use of follow-up prompts	-0.64	-1.83	0.54	0.88		
BCT19: Provide opportunities for social comparison	-0.16	-2.55	2.23	1.00		
BCT20: Plan social support/ change	0.54	-1.98	3.06	1.00		
Model 2					64.10%	45.55%
BCT8: Provide instruction	0.06	-0.55	0.66	0.82		
BCT10: Prompt specific goal setting	0.10	-0.58	0.60	1.00		
COPDspec	1.34	0.51	2.17	<0.01		
Model 3					75.58%	0.53%
BCT4: Prompt intention formation	-0.80	-1.78	0.17	0.36		
BCT10: Prompt specific goal setting	0.60	-0.19	1.38	0.42		
BCT11: Prompt review of behavioural goals	-0.64	-1.56	0.28	0.50		
BCT12: Prompt self-monitoring of behaviour	-0.25	-0.94	0.44	0.93		
BCT13: Provide feedback on performance	0.52	0.28	1.15	0.87		
Model 4					69.69%	22.90%
BCT4: Prompt intention formation	-0.53	-1.42	0.35	0.61		
BCT5: Prompt barrier identification	-0.44	-1.24	0.35	0.67		
BCT7:Set graded tasks	-0.70	-1.56	0.16	0.33		
BCT8:Provide instruction	0.82	0.07	1.57	0.10		
BCT9:Model/ Demonstrate the behaviour	-0.39	-1.32	0.54	0.89		

[a] 20000 permutations based on the Monte Carlo simulation

3.4 Discussion

The present review investigated the effects of interventions designed to increase physical activity in people with COPD outside of a pulmonary rehabilitation setting. Twenty-eight randomised controlled trials of interventions were included, which had a medium-to-large sized effect on physical activity (d_+ = 0.60). This effect is comparable to that found in previous reviews of formal PR programmes (Lacasse et al., 2002; Salman, Mosier, Beasley, & Calkins, 2003) and indicates that the programmes included in this analysis, that had less than two supervised sessions per week, can be effective in increasing physical activity. However, caution is warranted in the interpretation of this finding as studies with small sample sizes tended to report larger effects, so this could indicate that publication bias has inflated this effect size. In Study 2 (Chapter 2) it was possible to assess this by re-calculating the effect size without studies with small sample sizes, however in this case too few studies with large enough samples would remain. Future research should ensure adequate sample sizes are used, to allow this analysis to be completed in an update of this review.

Ten variables explained a significant amount of the variance in effect sizes. The largest amount of variance was explained by whether the studies had adequate or inadequate statistical power. This is not surprising considering studies with small sample sizes reported larger effects. When an effect size is large, a smaller sample size would be adequate to detect it, conferring higher power. The relatively high quality of the included studies could indicate that the effects accrue from the intervention delivered, and not other forms of bias in the designs. However, despite searching for grey literature, the absence of publication bias cannot be guaranteed.

Outside of sample size and power, seven other moderators explained a significant proportion of the variance in effect sizes. *Providing COPD specific information* explained over 50% of the variance in effect sizes. This finding indicates that programmes that incorporate elements such as advice on inhaler technique alongside the physical activity components might be more effective. It could be suggested that these multi-component interventions are more similar to established PR programs and that the effective combination of physical activity and education that has been identified in PR research is also applicable here. The multivariate regression analysis confirmed this finding (Model 2). Two of the BCTs (*Provide feedback on performance* and *Plan social-support/ change*) that were counter-indicated (had been associated with more effective interventions when absent than present), when looked at individually, became positively associated with effect size when included in the multivariate meta-regression. The change in sign when included in a multivariate analysis indicates there are unexplored relationships between the BCTs. As proposed by Michie et al., the effect of combining certain BCTs and study characteristics might also account for the high level of unexplained heterogeneity within the included studies (Michie, Abraham, et al., 2009). A recent paper has re-analysed the data extracted by Michie et al (2009) to specifically look for combinations of BCTs that are associated with greater effect sizes, and combinations that seem to reduce effect sizes (Dusseldorp, van Genugten, van Buuren, Verheijden, & van Empelen, 2013). Classification And Regression Trees (CARTs) were applied to the 122 interventions included in the original meta-regression; the authors refer to this process as a meta-CART analysis. Looking at model 3 presented in this chapter, the analysis could indicate that the BCT *provide feedback on performance* is more effective if delivered in conjunction with *prompt specific goal setting*, but without the other techniques associated with control theory, than it is when delivered alone (as the β coefficient changed from negative to positive when it was included in a multivariate model based on control theory components). However, using meta-regression there is no way to investigate the effects of *providing feedback on performance* delivered without any other BCTs, as all of the interventions used different combinations of BCTs. Meta-CART analysis could potentially provide this answer and represents an interesting methodological development in mathematically synthesising intervention studies. However a large number of primary studies are needed, and the 28 studies identified in the current review would be insufficient.

3.4.1 Limitations and future directions

The main limitation of the present analysis is the relatively small samples in the included studies, and the potential influence of publication bias on this analysis. There is a paucity of larger trials of interventions to promote physical activity in people with COPD, and studies with larger samples are needed to corroborate the findings reported here. Only three of the included studies met Coyne et al's recommended quality threshold of having at least 35 participants in each condition. To address potential publication bias, grey literature was searched, and the trim and fill method identified that no adjustment of the overall effect size was needed. The number of potentially eligible trials identified as 'currently recruiting' on clinicaltrials.gov indicate that this area of research is gaining in popularity, and in future years larger trials should be published which could be used to expand the present review.

In some cases important details about the intervention or the sample were not reported. For example, whether the participants had adhered to the proposed timetable of supervised and unsupervised sessions, or had completed a course of pulmonary rehabilitation prior to enrolling in the trial. In the future, better reporting of trials should address these points. The general limitations of coding for behaviour change techniques from published interventions described in Chapter 2 (section 2.4.1), would also apply here. In the current analysis, many of the proposed moderators did not influence effect sizes. It may be that additional details about the primary interventions may have identified moderators that had a greater impact on the heterogeneity.

The heterogeneity in effect sizes and the differences in intervention design between the primary studies could indicate a lack of consensus amongst researchers about the most appropriate approach to take to improve physical activity outside of pulmonary rehabilitation. A meta-regression has the potential to provide information that may lead to this consensus. However, to ensure validity, larger high quality studies are needed.

3.4.2 Conclusions

This chapter reported a meta-analysis with meta-regression that investigated the effects of interventions designed to increase physical activity outside of a formal pulmonary rehabilitation setting for people with COPD. The interventions identified were effective, producing a pooled effect size of 0.60. Provision of COPD specific information in addition to the physical activity components was identified as a significant predictor of effect size. However the findings of this review are mainly based on trials with small sample sizes; further high quality studies with larger sample sizes are needed to corroborate these findings and identify additional moderators of effect size to explain a greater proportion of the observed heterogeneity.

4 Study 3: Testing an existing persuasive technology with a COPD population: Background and Methods

4.1 Introduction

The review of existing technology-based interventions for PwCOPD in Chapter 1 showed that there are relatively few persuasive technologies designed for this population. The evidence related to efficacy thus far is from small pilot studies e.g. (Moy et al., 2010; Nguyen et al., 2008; Nguyen et al., 2009), however the maps and apps project (DoH, 2011) indicated that there is interest in developing technology for PwCOPD (see Section 1.3). This chapter follows steps one to six of the 8-step process for designing a persuasive technology (Fogg, 2009c) to describe how the reviews conducted influenced this research, how an existing technology was chosen as a suitable example, and the methodological approach taken to evaluating this technology. The results and discussion of this study are reported in Chapter 5. As described in Chapter 1, there are two key factors to consider when assessing a persuasive technology; first, the target users should find the technology both usable and useful, and engage with the technology. Secondly the technology should have the desired effect on attitudes and/or behaviours. As this research is in a developmental stage, both what effect the persuasive technology has on behaviour, and why these effects occur, are of interest. This chapter describes the background and methods of a series of *N*-of-1 studies, the results and discussion are presented in Chapter 5.

4.2 Background

According to Fogg, when looking to design a new persuasive technology, design teams should follow 8 steps (Fogg, 2009c;see Chapter 1, Figure 1.4). The first four steps concern defining the situation persuasive technology will be used in: Step 1, what behaviour it will target; step 2, what is stopping this behaviour from being performed currently; step 3 who will use the technology; and step 4, what technology channel[6] will be used. There is not a strict order in which these four aspects should be defined. It is further acknowledged that design teams may have certain restrictions placed upon them in terms of the target population or behaviour (Fogg, 2009c). Fogg suggests that success is more likely if designers choose: a simple goal initially, then build up to the targeted change; an audience that are likely to be receptive at the outset; and a technology channel that is familiar to the audience already.

[6] *Channel* in this context refers to the combination of hardware and software elements used to deliver the persuasive message, for example text messages on a mobile phone could be used, or an interactive game on a computer.

In the case of this thesis, the target population (PwCOPD) has already been decided (step 2). To decide on the target behaviour (step 1) a number of factors were considered. An intervention incorporating persuasive technology for people with COPD would need to compliment current services. It is therefore important to be aware of the current procedures and care available in the local area. Local HCPs, and relevant guideline documents were consulted to gain this awareness. Both smoking cessation and increasing physical activity (outside of PR) were confirmed as needed by the local HCPs. As discussed in Chapter 2, people with COPD who continue to smoke are directed towards the NHS Stop Smoking Services (SSS) to aid cessation and it was felt that although improvements to this service could be made to ensure the greatest efficacy specifically for PwCOPD, an intervention designed with the limited budget and time available was unlikely to represent an improvement on the existing service. In addition, a recent review and meta-analysis has found that interventions that include an exercise component significantly decrease symptoms of anxiety and depression, regardless of their severity (Coventry, Bower, Keyworth, Kenning, Knopp, Garrett, Hind, Malpass and Dickens, 2013). Depression is more prevalent amongst PwCOPD than controls (Zhang, Ho, Cheung, Fu and Mak, 2011), this discrepancy was not explained by differences in age, gender, respiratory function or current smoking status. The presence of depression has been found to be associated with both mortality and longer hospital stays for PwCOPD (Ng, Niti, Tan, Cao, Ong and Eng, 2007). An intervention that could increase physical activity therefore could have an effect on two important determinants of health for this population. The remainder of this thesis therefore will focus on increasing independent physical activity, as it was thought there was greater need in this area, and there are wide ranging benefits of increasing activity for this population. As described in Chapter 1, although there are not many studies investigating the use of persuasive technology in people with COPD, there is some evidence that it is both acceptable (Burkow et al., 2008; Finkelstein, Khare, Vora, & Arora, 2003; Johnston, Nguyen, & Wolpin, 2009) and feasible (Moy et al., 2010; Nguyen et al., 2008b; Nguyen, Gill, Wolpin, Steele, & Benditt, 2009) to deliver a physical activity intervention through technology to people with COPD.

Step 2 is to identify the reasons the behaviour is not currently being performed. As there are many existing research studies investigating the barriers to, and facilitators of, physical activity in PwCOPD, it was decided this question was best answered through a review of the existing literature, rather than an additional primary study in this area. A scoping review (Armstrong et al., 2011) was performed and the barriers and facilitators identified were classified according to the COM-B model (Michie, van Stralen, et al., 2011; Porcheret & Main, 2011). A wide range of barriers were identified related to PwCOPD's: physical capability (breathlessness, severity of

COPD, fatigue, exercise capacity, exacerbations and presence of co-morbid conditions); psychological capability (poor coping skills, depression, low mood, anxiety and fear); physical opportunity (a lack of time and unsuitable weather); social opportunity (embarrassment, stigma and loneliness); automatic motivation (lack of self-esteem/ self-efficacy and frustration; and finally reflective motivation (perceptions for illness and perceptions of health). See Appendix II for further details of this review.

4.3 Identifying the technology

Step 4 in the 8-step process is to decide on an appropriate technology channel. This includes the software elements that will be delivered, as well as the hardware used to deliver them. As described in Chapter 1, the use of BCTs derived from a known theory (or several theories) can help to understand why a BCI either works, or does not. Two approaches to identifying BCTs were outlined i) to identify which elements of the COM-B model needed addressing, then use the behaviour change wheel to identify which interventions, functions, and BCTs would be useful to address them and ii) to use meta-analysis and meta-regression to assess previous interventions and identify BCTs associated with effectiveness. The review of barriers and facilitators identified that there were barriers in all the components of the COM-B. This highlights the complexity of physical activity behaviour in PwCOPD, but does not help to narrow down the potentially useful BCTs. Furthermore, although the behaviour change wheel has been designed to be used in this way, at the time of this review the links between the intervention functions and specific BCTs were not established. Therefore while the review of the barriers and facilitators was valuable to increase understanding of the target behaviour and population, it did not help to identify relevant BCTs for the technology channel.

Study 2 (reported in Chapter 3) identified that BCIs that delivered both physical activity and other components together seemed to be the most effective for PwCOPD. In addition, the review highlighted that research in this area has so far relied on small samples, and under-powered pilot studies. There was no clear evidence relating to which BCTs, or theoretical framework might be the most effective. In a review of 122 interventions, Michie et al., found that, in a general population, self-monitoring was an effective BCT in interventions targeting physical activity and healthy eating behaviours (Michie, Abraham, et al., 2009). In addition, the effectiveness of self-monitoring was improved by adding any BCT derived from Carver and Scheier’s control theory (Carver & Scheier, 1982; Michie, Abraham, et al., 2009).

Control theory originated in the field of cybernetics but has been applied to the self-regulation of health behaviours since the 1980s (Carver & Scheier, 1982). The theory is based on the idea of a 'discrepancy reducing feedback loop' (Carver & Scheier, 1982, p.111). This loop suggests that someone monitors their behaviour, compares this information to a desired reference value (i.e. a goal), makes a decision based on this comparison (to either increase or decrease behaviour), and continues this process in an ongoing process of self-regulation (Carver & Scheier, 1982). The BCTs derived from control theory are *prompt self-monitoring of behaviour*, *prompt specific goal setting*, *provide feedback on performance* and *prompt review of behavioural goals* (Abraham & Michie, 2008). Many of the mobile phone apps that incorporate persuasive technology, and that are available for the general public to increase physical activity, include self-monitoring, goal-setting and other BCTs derived from control theory (see Chapter 6). As there is currently little evidence related to the efficacy of this approach using persuasive technology, but there is evidence of its efficacy in other BCIs, from the perspective of developing persuasive technology, control theory would be an interesting theory to investigate.

In addition, there were practical advantages to using control theory as the theoretical framework for the empirical work that follows, as researchers in the same department already had a pieces of persuasive technology designed as part of a previous research project called SMART2. There were three systems originally designed for the SMART2 project, one for chronic pain, one for stroke, and one for congestive heart failure (CHF). All aimed to change health-related behaviours using a variety of BCTs associated with control theory, and other theories, as well as other approaches such as computerised cognitive behavioural therapy. All the systems were considered for their suitability and the BCTs and persuasive technology techniques used by each were identified. The system targeting CHF (Burns et al., 2010) was considered the most suitable. This was therefore identified as a relevant example of persuasive technology to test (Step 5 in the 8-step design process). Although COPD and CHF have many differences, there are similarities as well: both are chronic conditions, most prevalent in older adults; both require a complex array of self-management behaviours to be adopted and maintained to ensure the best health outcome (Barlow et al., 2002); and in both cases one of the key self-management targets is to maintain an appropriate level of physical activity (National Institute of Health and Clinical Excellence, 2010a). It was thought that it would be relatively easy to tailor this technology for the COPD population by removing specific CHF content (such as educational material and symptom monitoring) and tailoring the specific goals set to be appropriate for PwCOPD. Throughout this tailoring process it was necessary to monitor that the desired BCTs associated with control theory were not compromised. Originally, the SMART2 CHF system had incorporated several hardware elements, a touchscreen computer, and a mobile device forming the core system, with peripheral sensors for measuring weight and blood pressure. During the course of tailoring this technology it was identified that all the desired BCTs for the current study could be delivered using the mobile device alone. This was thought to be preferable as previous feedback had indicated that participants with CHF had found the touch screen computer bulky to have in their homes. During the transition to delivering the intervention solely on the mobile device it was again essential to ensure that the BCTs were delivered appropriately. Using this technology would enable an initial test of the technology, and these BCTs, with PwCOPD. The results from this, together with the barriers and facilitators identified above, and the findings from Study 2 and 4, could then be used to further refine and re-design the technology in the future. This decision making process led to the technology channel being defined as a mobile device to deliver BCTs derived from control theory (see Table 4.1 and Figure 4.1).

The final steps in the 8-step design process encourage designers to try and reproduce what makes the previous technologies successful in the current design setting; then to test this design, and iterate the design, testing, re-design process quickly until designers find something that works. Finally, researchers/designers are encouraged to expand on this success by including other populations or building up the target behaviours (Fogg, 2009c).

Table 4.1: Behaviour change techniques, definitions and how they are delivered in the current research

Technique[1]	*Definition*[1]	*Delivery*
Prompt specific goal setting	Involves detailed planning of what the person will do, including a definition of the behaviour specifying frequency, intensity, or duration and specification of at least one context, that is, where, when, how, or with whom	Participants set daily (frequency) walking goals. Defined in terms of the length of time (duration). Context was decided by the participant e.g. walking the dog, or walking on a treadmill at home.
Prompt review of behavioural goals	Review and/or reconsideration of previously set goals or intentions	Following the daily goal being completed, participants were asked to rate it as ‘Too Little’, ‘Just Right’ or ‘Too Much’
Prompt self-monitoring of behaviour	The person is asked to keep a record of specified behaviour(s) (e.g., in a diary)	The record is kept by starting the walk using the phone, then carrying it on the walk.
Provide feedback on performance	Providing data about recorded behaviour or evaluating performance in relation to a set standard or others’ performance, i.e., the person received feedback on their behaviour	Feedback was in the form of an onscreen graph that could be viewed for the last week, since they had started using the phone, or the complete month.

[1] Technique names and definitions from (Abraham & Michie, 2008, p.382)

To understand how the persuasive technology, combined with the control theory elements, influences outcomes, the physical activity component of the SMART2 technology was separated from the other components that were exclusive to heart failure (e.g. the education section). The physical activity component was then coded for the presence of persuasive technology techniques using the persuasive systems design model (Oinas-Kukkonen & Harjumaa, 2009). The persuasive technology techniques identified included elements of primary task support, dialogue support and credibility support (see Chapter 1 Section 1.1.2 for further detail on these classifications). Primary task support was provided through *tunnelling* of individual tasks, *tailoring* of goals and feedback based on the individual, and the *self-monitoring* of the user's activity mentioned above. Dialogue support was provided through *praise* delivered upon meeting set goals, and attention was paid to *liking* throughout the user-centred design process. Credibility support was provided by incorporating *expertise*, *surface credibility* and *third-party endorsements,* achieved through a combination of a professional looking system with University of Sheffield logos in the accompanying materials.

In Section 4.2 Fogg's recommendations for developing persuasive technologies have been described; when considering the technology channel (step 4), he recommends choosing a technology that is already familiar to the target audience. The current research deviates from the recommendations on this point, by providing a touchscreen mobile device that may be new to some users. The rationale for this deviation is two-fold. First, it is difficult to identify any persuasive technology that all PwCOPD would currently be familiar with. Persuasive technology by definition must be interactive (Fogg, 2003), and in addition to this, as a research project, information needs to be sent from the device to the research team. Even a technology familiar to the majority of older adults like the television, once it becomes interactive and able to send information (e.g. a Smart TV) may become unfamiliar to many. Second, as this research is at the developmental stage, the final application of these findings might not be for a number of years; limiting the research to devices that older adults are currently familiar with (if these could be identified) risks making the research obsolete in a relatively short time period. Fogg suggests the use of familiar technology to ensure initial engagement is not a problem. In this study engagement is assessed so the potential impact of an unfamiliar technology will be explored.

4.3.1 Evidence from developmental stage research

Although Fogg and colleagues recommend the quick iteration and design of technologies (with tests lasting only a few hours), this is impractical in a health setting with PwCOPD, and as this research is at a developmental stage it would not give sufficient information about why the technology either worked, or did not work. There is disagreement regarding the most appropriate methodology to follow in future trials of technology in a health setting (see Section 1.3). Some authors advocate the use of large scale RCTs to aggregate data across a large number of individuals to find the overall effect of technology (McLean et al., 2011; Smith et al., 2009). However, in averaging results across individuals, the overall effect might not be representative of individuals within the group (Barlow, Nock, & Hersen, 2009; Molenaar, 2007). This can cause problems when clinicians try to apply the findings of large trials to individual care (Molenaar & Campbell, 2009). Furthermore, as can be seen from Studies 1 and 2, while RCTs can provide efficacy information, frequently they do not report what the *active components* of complex interventions are (Abraham & Michie, 2008), or why interventions seem to work for some individuals and not for others (Osthoff & Leuppi, 2010). RCTs are still seen as the *gold standard* for evaluating established interventions, however in the 2008 MRC guidance for designing and evaluating complex interventions, it is argued that during the early stages of research, the iteration of development, piloting and evaluation might be better served by methods that provide early indications of effectiveness (Craig et al., 2008).

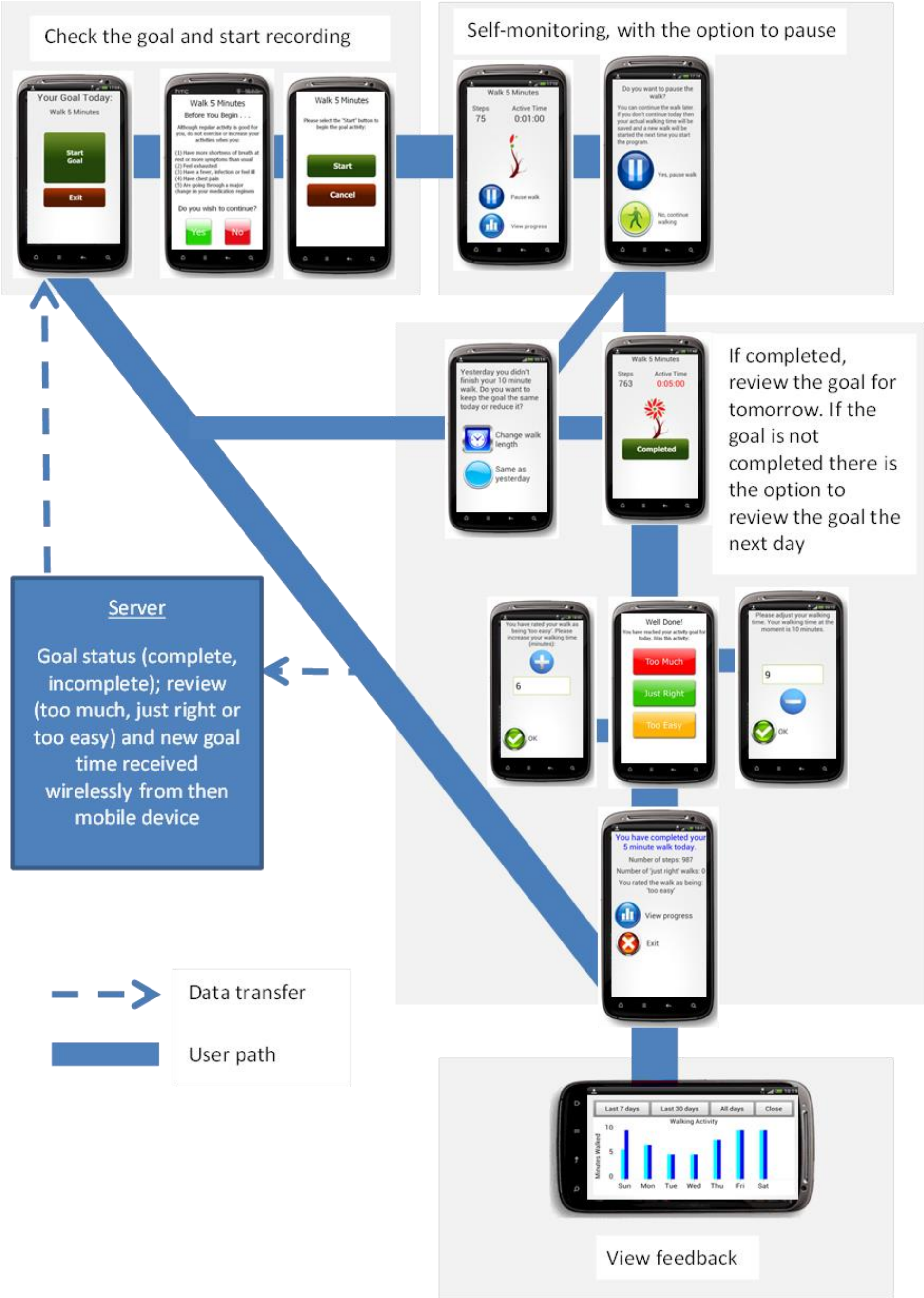

Figure 4.1: Behaviour change techniques delivered through a smart phone mobile device

One approach to providing this initial evidence is to conduct a small scale pilot study, following an RCT methodology, but with a small number of participants. This approach has been taken by a number of researchers assessing similar technology to increase physical activity in people with COPD (see Section 1.3). While this approach provides evidence of feasibility of the trial design, and can provide evidence for the validity of certain trial components, the evidence provided for the effectiveness of the intervention is more equivocal. Nguyen et al., assessed whether a mobile phone based self-monitoring system with coaching elements would be more effective at maintaining exercise levels post-rehabilitation than the self-monitoring intervention alone (2011). They did not find a significant between-group difference in their pilot study of 17 people; however they make the point that '[this] finding needs to be interpreted with caution since this was a purely exploratory study' (Nguyen et al., 2009, p.301). In another example Moy et al., looked at change in step count over time in a group of 16 people with COPD using an internet delivered walking programme and a pedometer (Moy et al., 2010). They found a significant difference in step count over time and reported a change in *average* daily step counts of 988 ± 1048 steps[7]. This gives a positive indication that the majority of the 16 people with COPD made improvements to their step count. However, it also indicates wide variability in the change scores within the sample, including some people who walked fewer steps during the intervention than previously. As all the analysis is conducted at a group level there is no explanation of how the scores were distributed across the sample and whether there were any outliers that might have affected the mean, or range reported. Furthermore, as all the data collected was quantitative there is no way of understanding why the intervention worked better for some of the 16 than others. As with the Nguyen et al., paper, the main purpose of the study was not to provide efficacy evidence. Moy et al., validated the Omron HJ-720-ITC pedometer for use with people with COPD. However, by reporting underpowered statistical analysis from pilot studies the results could be misleading (Arain, Campbell, Cooper, & Lancaster, 2010).

The alternative to providing evidence through small pilot studies is to focus instead on a detailed study of an individual. Designs that focus on the individual are not intended to replace large scale RCTs but either pre-date and inform them (Borckardt et al., 2008), or can be presented alongside them (Dattilio, Edwards, & Fishman, 2010)

> *'Case-based time-series designs will not dissolve the formidable epistemological gap between practice and research, but their use can help bring the two disciplines within shouting distance of each other on a more regular basis' (Borckardt et al., 2008, p.91)*

4.3.2 Methodological approaches to studying the individual

Studying the individual has a long history in psychology (Kazdin, 1981) and the terms used to describe this approach are not currently universally defined. For Nock et al., *N*-of-1, single case research designs, or single-subject research can be used inter-changeably to describe a family of methods (Nock, Michel, & Photos, 2007). The key identifiers of these studies are that they

[7] It is not clear from the article whether this figure indicates a mean and standard deviation or a median and range. In earlier tables in the publication both age and BMI (Body Mass Index) are reported as mean ± SD but as this is not specified for step counts it is unclear

describe an individual[8], rather than groups. The individual is the unit of analysis, and, if comparisons are made, they are made *within* the individual, rather than between-individuals (Schlosser, 2009). Within this individual focussed group of methods there is variety in the exact design used, how internal and external validity are approached and whether they constitute case studies, quasi-experimental designs, or experimental designs (Nock et al., 2007). Internal validity has been described as 'why the inferences on the effect of a given independent variable can be incorrect' and external validity as 'how the inferences can be generalised across populations, contexts etc.' (Ramos-Álvarez, Moreno-Fernández, Valdés-Conroy, & Catena, 2008, p.753). By adding features of experimental design (such as; a replicable intervention, random allocation, control conditions, repeated observations), the researcher is increasing the control they have over the study and with that the internal validity; so the researcher can be more confident that if they find a change in effect, there is likely to be a causal link to the intervention, rather than a naturally occurring change over time (Nock et al., 2007). However, as features of experimental design are added, studies can become more costly and time consuming. Quasi-experiments aim to find a balance between validity and feasibility. However, the lines between experimental and quasi-experimental designs are also unclear. Nock et al., define quasi-experimental designs as requiring a well-specified replicable intervention, and repeated measurements across time. The addition of a baseline phase (for comparison to the intervention) makes a design experimental (Nock et al., 2007), and this is in agreement with the definition given by Barlow et al., of single case experimental designs (SCEDs; Barlow et al., 2009). However in a recent systematic review of SCEDs, any studies that did not use random allocation in addition to baseline and repeated observations were excluded as quasi-experimental designs and not SCEDs (Smith, 2012). *How* experimental a design needs to be to be defined as an SCED therefore is not clear. The term *N*-of-1 also has this problem of definition; while Nock et al., use *N*-of-1 as an equivalent of a case study, the definition of *N*-of-1 trials given by the MRC includes that the order of interventions should be decided at random (Craig et al., 2008); these designs are referred to elsewhere as *N*-of-1 RCTs (Schlosser, 2009).

This evidence shows that researching the individual can provide evidence on a spectrum, from observational case-studies to *N*-of-1 RCTs. As the terminology in this area is not well-defined, often the term given to describe a design is not enough to understand how the research was carried out. Until a standardised description is agreed upon, a full description of the method should enable appropriate interpretation of the results. The current study investigates the

[8] The individual is most commonly one person, however it could also apply to one hospital or one workplace.

effect of a persuasive technology intervention on the number of steps walked by people with COPD. The intervention is fully described and it is a mixed methods study collecting both interview data and objective outcome data collected repeatedly over a baseline and experimental phase; the term *N*-of-1 will be used to describe this. Mixed methods research allows an examination of both the process and the outcomes of an intervention, providing the opportunity to gather an explanatory account alongside the quantitative findings (Plano-Clark, 2010). This rationale for using mixed methods has been termed the *completeness* rationale (Bryman, 2008). Mixed methods research relies on both *strands* of the research (qualitative and quantitative) to be conducted and analysed appropriately, then integrated appropriately (Tashakkori & Teddlie, 2008). Effective integration of strands is intended to increase the *knowledge yield* of mixed methods research above what is possible from considering the two strands separately (Bryman, 2007; Creswell & Plano Clark, 2011; O'Cathain et al., 2010). In this case as the individual is the unit of analysis, findings were integrated within each individual. The data was collected concurrently (quantitative first), and is presented according to three areas of interest; i) personal context, ii) engagement and experience of use and iii) behaviour change (see Section 5.1).

4.3.3 Aim

The aim of this study is to investigate the effect of using a persuasive technology based on control theory BCTs on walking behaviour in people with COPD.

4.4 Method

4.4.1 Population

Participants were recruited from Breathing Space, a specialist NHS centre that provides both inpatient and outpatient care to people with COPD in Rotherham, South Yorkshire. The pulmonary rehabilitation offered at Breathing Space is an eight week course, with three visits per week to the on-site gym, and eight education sessions. A combination of aerobic (treadmill, bike, rowing machine, cross trainer) and strengthening exercises using various hand weights is encouraged. Exercise capacity is gradually increased over the weeks by extending the time spent on each activity, and altering other factors such as, the speed, or incline of the treadmill. There are a range of options available for people with different levels of starting ability and the programme followed is tailored to each individualFollowing the formal pulmonary rehabilitation programme, individuals can attend weekly maintenance sessions. These are at the same gym, but there is no formal programme to follow, instead individuals are expected to decide for themselves what they can, or would like to do and record cards can be filled out and referred to in later weeks. Between 2007-2009 336 PwCOPD were referred to the high intensity programme of pulmonary rehabilitation at Breathing Space (described above, as appose to the low intensity programme, or Activities of Daily Living programme), 237 of these attended at least one session, and 198 attended ≥12 sessions, 117 of these continued onto maintenance classes (35% of those initially invited; Reddington, Telford, Stott & South, 2009).

Participants were recruited following completion of the high intensity programme of pulmonary rehabilitation, while they were attending maintenance classes. There were both scientific and safety reasons for this decision. The SMART 2 system is not designed to *motivate* a change in physical activity behaviour, instead it is a tool designed to *enable* those already motivated, to undertake the volitional phase of behaviour change (Heckhausen & Gollwitzer, 1987). Completing the pulmonary rehabilitation course and attending maintenance classes indicates a high level of motivation to maintain a healthy level of physical activity. This should also ensure that the audience is receptive in terms of the target behaviour suggested (step 2 in the 8-step design process to design persuasive technologies; Fogg, 2009c). The lead physiotherapist at Breathing Space was also consulted and felt that this point in the pathway would ensure the participants recruited were knowledgeable about what a safe level of activity felt like (as they are taught this in rehabilitation), and could undertake the walking intervention safely.

People attending Breathing Space were eligible to take part in this study if they a) had a diagnosis of COPD; b) had completed a course of pulmonary rehabilitation in the last 6 months c) had no known cognitive difficulties that would impair understanding of the information sheet or consent form and d) had an understanding of written and spoken English. These criteria were confirmed by the physiotherapist responsible for their care.

4.4.2 Sample Size

As the analysis takes place within an individual, the power and sample size calculations for *N*-of-1 studies aim to identify the number of measurements rather than number of people required to detect an effect (Barlow et al., 2009). As this is a new technology, and there is little reliable efficacy data for physical activity change in PwCOPD, a pre-existing estimated effect size could not be identified. Instead, the procedure outlined in a similar study with a healthy population was used (Sniehotta, Presseau, Hobbs, & Araújo-Soares, 2012). Cohen's rule of thumb was used to estimate that 30 readings per comparison arm would be suitable to produce 80% power (Cohen, 1988). As step counts are taken daily by the pedometer, this equated to a 30 day baseline period, and a 30 day intervention period. It should be noted that this was an estimated sample size as Cohen's rule of thumb was calculated for independent samples[9]. As this study was not being powered to detect between-subjects effects, the number of *N*-of-1 studies was not decided statistically. The number of SMART systems available limited the number of trials to ≤10.

The sample was an opportunistic sample of seven participants. Although the recruitment period was extended from 3 to 7 weeks, no further participants agreed. Feedback from the recruiting physiotherapists and physiotherapy assistants was that the length of the commitment required was the main reason for decline. No record was kept of how many people were approached about the study, so a response rate could not be calculated.

4.4.3 Ethical Considerations

As previously mentioned, the safety of potential participants was considered throughout the design, recruitment and delivery of the intervention and advice from the direct care team was acted on. In addition, each participant provided informed written consent. The initial approach was made by a member of the direct care team, and they provided an information sheet (see Appendix II), if the individual with COPD was willing to speak to a researcher, the thesis author met with them at Breathing Space following their next maintenance class. Following this initial contact, a potential start date for the intervention was planned. Interested individuals had the information sheet with the thesis author's contact details on it and the researcher rang ahead of the appointment to see if the person was still interested and to answer any questions. This procedure gave potential participants time to think about the study before consenting. Once consented, letters were sent informing the participants' GPs of their involvement. Ethical approval for this study was granted by the NRES Committee South Central – Oxford A and R&D approval was given by the Rotherham NHS Foundation Trust (see Appendix II for approval letters)

4.4.4 Outcomes and Analysis

Primary outcomes were the engagement with the system, the experience of using it, and the change in the number of steps walked from the baseline to the experimental phase. Secondary outcomes were the amount of moderate intensity activity undertaken by participants and the level of self-efficacy for exercise self-regulation. Both qualitative and quantitative data were collected and combined within an individual as an integrated mixed methods *N*-of-1 study.

Engagement with the system

[9] The Cohen calculation was found to be appropriate in six of the seven cases reported here as there was no significant autocorrelation between the step counts for these participants. Future research should however consider the impact this method of sample size calculation could have if greater autocorrelation was found.

The mobile device recorded information related to the number of goals set, how often the phone was used to monitor a walk, and how often a walk was rated (as too much, just right or too easy), The thesis author was emailed a summary of this information daily and it was used as an indicator of engagement.

Experience of the system

An exit interview was conducted to assess participants' experience of using the technology (see Appendix II for topic guide). The interview covered aspects relating to physical activity; experiences of using the blinded pedometer; experiences of using the mobile device; and overall experiences and suggestions for improvements to the technology. The interviews were recorded, transcribed verbatim by the thesis author, and NVivo 9.2 (QSR International Pty Ltd, 2010) was used to conduct a thematic analysis (Braun & Clarke, 2006).

Usability was also quantitatively evaluated through the Systems Usability Scale (SUS; Brooke, 1996). This is a short scale that is quick to complete and is not specific to any particular type of technology, making it ideal for new software. In a review covering 10 years of use Bangor et al., found 'the SUS is a highly robust and versatile tool for usability professionals' (Bangor, Kortum, & Miller, 2008, p.1532). The common use of this scale also allows the usability of this system to be compared with others.

Measuring the number of steps

This outcome needed to be measured daily for 60 days (30 day baseline phase and 30 day experimental phase, as calculated in section 4.4.2). There were several factors that had to be taken into account to choose an appropriate device to measure step count. First, as the act of measuring can change the behaviour being measured (Yanovitzky & VanLear, 2007), the baseline needed to be as naturalistic as possible. Second, as self-monitoring was one of the BCTs being investigated, it was important that the baseline period did not allow the individual to benefit from receiving feedback from self-monitoring, as this could have changed the participant's behaviour. Finally, it has been reported that people with COPD walk significantly slower than healthy adults (Pitta, Troosters, Spruit, Decramer, & Gosselink, 2005) therefore, it was also important the device used was sensitive enough to be accurate at slower walking speeds. The Omron HJ-720ITC pedometer was chosen because it has previously been found to capture >80% of the steps taken by people with COPD (Moy et al., 2010); has a 41 day memory (so no download would be needed mid-phase, making the baseline as naturalistic as possible), and it was affordable. To ensure participants were not self-monitoring during the baseline phase, the screen of the pedometer was covered with a sticker as in a previous study (Sniehotta et al., 2012).

Change in step count analysis

As the step count is objectively measured, repeated at regular intervals and taken across time from the same individual, it can be described as time-series data. In this study the time-series is split into a baseline phase and an intervention phase, creating what is referred to as *interrupted time-series* data (Ferron & Rendina-Gobioff, 2005). Each step count (1 day for 1 person) is counted as a data point. There are two over-arching approaches to analysing time-series data: visual analysis and statistical analysis. Visual analysis involves looking to see if there are any noticeable differences, in the level or the trend of the data, in the baseline or experimental phases. This method of analysis relies on an individual researcher's own judgement and, even if the researcher is well practised in this technique, it can be difficult to identify changes if they are small, or the data within each phase is very variable (Smith, 2012).

Time-series data is challenging to analyse statistically as many tests assume data points are independent. However a person's step count over consecutive days is unlikely to be independent. The relationship between data points in a time-series is called autocorrelation. Autocorrelation is described in terms of lags, or how many points around the data point of interest affect it. For example, if only the step count on Tuesday affected Wednesday's step count it would be defined as autocorrelation at lag 1; if the step count on Monday was also related to the step count on Wednesday this would be lag 2. Autocorrelation can be dealt with by either cleaning the data to remove it, then treating the points as independent by using a process such as regression (Quinn, Johnston, & Johnston, 2013; Sniehotta et al., 2012) or incorporating it into the assumptions of a time-series model (Yanovitzky & VanLear, 2007), or a statistical control chart (Mohammed, Worthington & Woodall, 2008). One reason why incorporating auto-correlation may be preferable is that regression analysis assumes a linear trend, and time-series data can show quadratic or other trends over time (Tabachnick & Fidell, 2001). A statistical control chart aims to identify abnormal variation in measurements as distinct from normal variation, for example a diabetic's blood sugar is likely to vary day to day, but large (or abnormal) variations may be cause for concern. Producing a control chart involves estimating a mean for the time-series data, and acceptable limits of variation (usually three standard deviations above and below the mean) then identifying measurements that fall outside of these control limits (Mohammed et al., 2008). This method of analysis is well suited to continuous monitoring over a long period of time, where each case of abnormal variation is of interest. In this case however, an individual day with a step count either above or below the expected variation is not as important as a continuing trend in step counts (ideally increasing during the intervention period).

The approach suggested by Tabachnick and Fidell is using an Auto-Regressive, Integrated, Moving Average model, an ARIMA model (Box, Jenkins, & Reinsel, 1994). An ARIMA model assess trends within the data and establishes whether changes are associated with the intervention time period. An ARIMA model has three components, represented by the letters *p, d & q.* These indicate the level of autocorrelation present (*p)* e.g. lag 1 ,lag 2; the type of trend present (*d*) e.g. 1 indicates linear, 2 indicates quadratic; and the moving average term which defines how much of the preceding data is used to predict future values including both the mean and any deviations from the mean (*q*) e.g. 1 or 2 deviations should be taken into account (SPSS Inc., 2009). In SPSS 17.0 (SPSS Inc., 2009) there is an expert modeller program which analyses the time-series data points and identifies the most appropriate values for each of these components for each time-series. To identify whether there was a significant difference between the baseline and the experimental phases, phase was defined as an event. Setting phase to '1' for the experimental data points and '0' for the baseline identifies for the model a period of time when the researcher believes something may be having an effect on the time-series. The model then ascertains whether the data points associated with the event are significantly different to those not associated with the event. A separate model is built for each participant. Participants were given a diary sheet to record if they forgot to wear the pedometer for a day, or a period of time within a day; these diary sheets identified days that were treated as missing data and removed from the final data analysis.

Secondary outcomes

A demographic questionnaire was designed, that collected information to describe the sample in terms of MRC breathlessness grade and current use of technology (see Appendix II: v). The level of moderate intensity exercise was collected using the Community Healthy Activities Model Programme for Seniors (CHAMPS) Activities Questionnaire for Older Adults. This questionnaire has been designed for use with the CHAMPS programme (see the CHAMPS website at http://dne2.ucsf.edu/public/champs/index.html for further details about the programme), and is tailored for use with older adults. The CHAMPS questionnaire relies on recognition of activities rather than free recall, which aids memory; it uses lay terms to describe intensity (e.g. brisk or leisurely walk), so doesn't assume any special knowledge; and there are a range of high and low intensity activities, so all participants should be able to answer 'yes' to some activities. This aims to reduce social desirability in responding (Stewart et al., 2001). It is hoped that these features would assist in gaining honest and accurate answers about the amount of activity being performed. In addition to being validated with a general older adult population (Resnick, King, Riebe, & Ory, 2008), this questionnaire has also been used previously with a COPD population (Berry et al., 2010; HajGhanbari, Holsti, Road, & Darlene Reid, 2012). The frequency and calories expended on all exercise, and specifically for moderate intensity exercise, can be calculated from the CHAMPS data (Stewart et al., 2001).

Effective self-management of COPD requires an individual to have knowledge, skills and confidence; it has been found that improving self-efficacy for specific tasks within an intervention can improve behaviour changes (Bourbeau et al., 2004). In fact, successful self-regulation of activity is thought to both contribute to, and be reliant on, self-efficacy (Bandura, 1991). To investigate whether an intervention that aims to encourage self-regulation of physical activity has any effect on exercise self-efficacy, the Exercise Self-Regulatory Efficacy Scale (Ex-SRES) was used (Davis, Figueredo, Fahy, & Rawiworrakul, 2007). This scale was thought to be the most appropriate as out of the three COPD specific self-efficacy scales identified in a recent systematic review (Frei, Svarin, Steurer-Stey, & Puhan, 2009), it was the only exercise specific one. The questionnaire presents the statement 'I believe that I could exercise 3 times a week for 20 minutes' followed by 16 different circumstances, for example, 'If I feel aches and pains while exercising' or 'If I feel stressed'. Participants rate each statement by circling increments of 10% (i.e. 10%, 20%, 30% etc.). There are verbal anchors above 0% (not at all confident), 50% (moderately confident) and 100% (highly confident). All the statements represent a single construct (Davis et al., 2007), therefore a single score of 0-100 is calculated by averaging the scores across the 16 statements.

4.4.5 **Study Procedure**

The study required participants to fill in questionnaires on three occasions, meet with the researcher either 3 or 4 times, carry a blinded pedometer for 60 days, interact with the mobile device daily for 30 days and complete an exit interview. A description of each meeting is provided in Figure 4.2. At Meeting 1 participants were asked to complete three questionnaires: the demographic questionnaire, the CHAMPS (Stewart et al., 2001) and the Ex-SRES (Davis et al., 2007). At Meeting 2 participants were asked to complete the CHAMPS and the Ex-SRES and at Meeting 3 participants were asked to complete the CHAMPS, Ex-SRES and the SUS (Brooke, 1996). At Meeting 2 when the mobile device was introduced the researcher worked through an instruction manual with the participants, which included: an overview of the system; contact details; instructions relating to both the mobile device, and the SMART software; and troubleshooting pages. The guide was presented in full colour with actual size screen shots; and was left with the participants for the duration of the study.

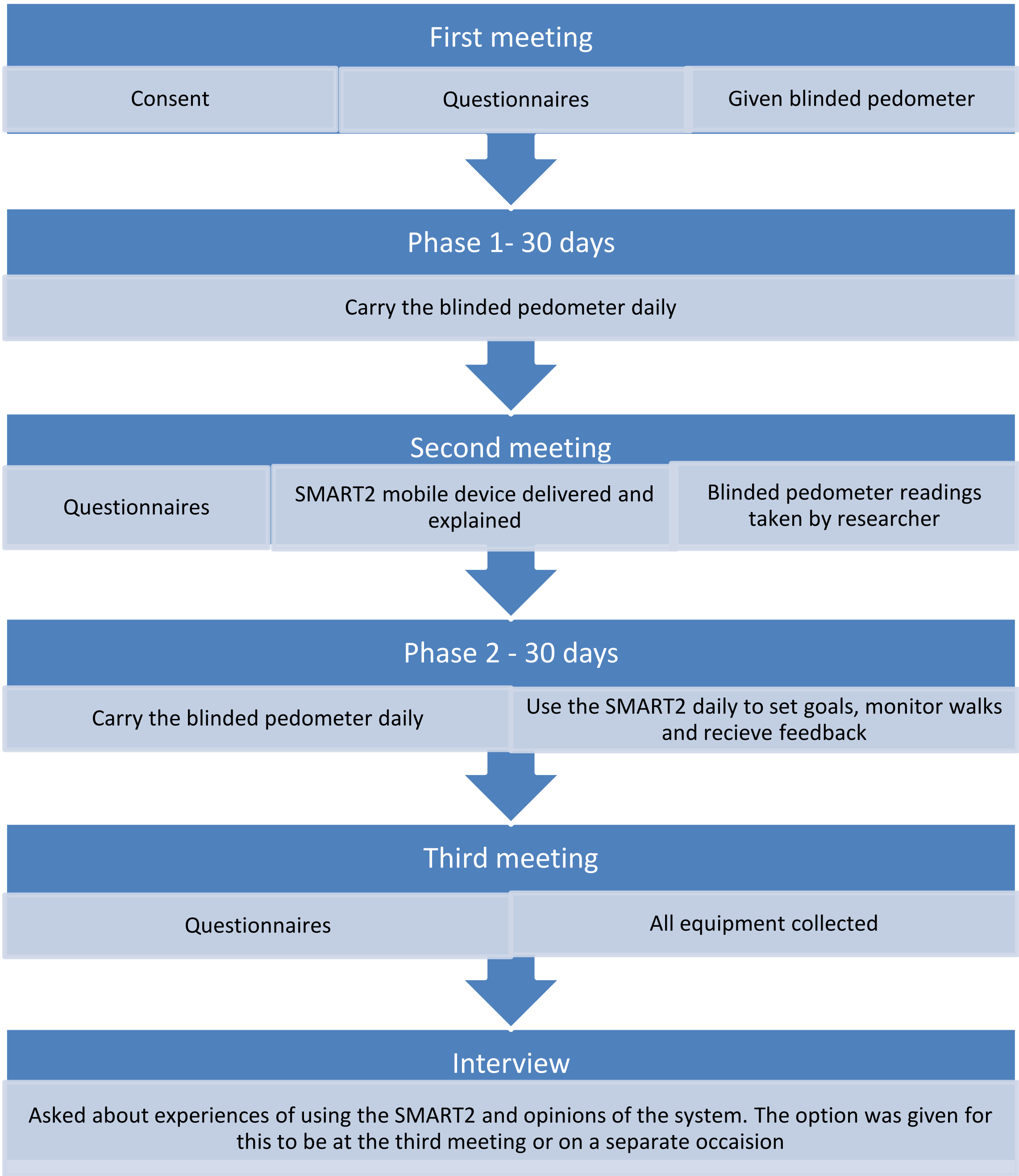

Figure 4.2: Procedure for the *N*-of-1 study

5 Study 3: Testing an existing persuasive technology with a COPD population: A series of *N*-of-1 studies

5.1 Results

As described in Chapter 4, the results are presented as integrated mixed methods case studies for each participant. The case studies are presented in three sections; i) personal context, ii) engagement and experience with the system, and iii) behaviour change. The personal context is described from the interviews and the demographic questionnaire; engagement and experience is described including factors relating to the mobile device use, the goals set, the perceived usability and SUS score (see Table 5.1 , Table 5.2, Table 5.3, Table 5.4, and the Figures that show the feedback screens for each *N*-of-1 study). Finally, behaviour change is described using the change in step counts (see Table 5.5) and the interrupted time-series models of the step counts, with the qualitative description of perceived change and perceived mechanisms of change. The case studies are followed by an overview of the results to explore the reasons why the same BCTs, delivered using the same BCI may have produced different effects. This type of integrated mixed methods *N*-of-1studies is typically seen in psychotherapy, where similar questions are explored relating to treatments; not only does it work, but why might it work and how do people experience it (i.e. Kellett & Hardy, 2013). Full case studies for each of the 7 participants are presented for completeness.

Table 5.1: Participant Demographics

Participant	*Age*	*Gender*	*MRC*[1]	*Time since diagnosis*	*Mobile use*	*Computer use*
1	65	Female	5	15 years	Every day	Every day
2	66	Male	3	8 years	Every day	Every day
3	77	Male	1	6.5 years	Every day	Every day
4	67	Male	1	5 years	Every day	Every day
5	59	Male	5	11 years	Every day	Every day
6	69	Female	2	7 months	Less than once a week	Once a week
7	71	Female	3	3 years	Every day	Less than once a week

[1] See Appendix II for definitions of MRC grades; 1=least severe, 5=most severe

Table 5.2: Scores from the CHAMPS, SUS and Ex-SRES questionnaires by visit

Ppt	Calories expended per week doing all exercise related activities (of these calories expended doing moderate intensity exercise)			Approximate hours per week spent doing moderate intensity activities[1]			SUS Score[2]	Ex-SRES[3]		
Meeting	1	2	3	1	2	3	3	1	2	3
1	1746(0)	979(315)	1579(531)	0	1	1.5	90	62.5	65	69.38
2	2259(1800)	4663 (2892)	4663 (2559)	6.75	13.75	9.5	100	76.88	60.63	50.63
3	13845(9744)	17831(12151)	10800 (5793)	28.75	44	18.5	100	100	92.5	100
4	5837(4414)	7940(3623)	3977(2054)	10.25	10.25	5	90	85	75.63	79.38
5	781 (88)	214 (88)	428 (88)	0.5	0.5	0.5	55	50.63	36.5	46.5
6	4038 (2180)	2180 (1546)	2492 (1387)	6.25	4.25	4.25	45	100	96.88	58.13
7	1541 (268)	2585 (1005)	4512(2290)	1	3	7.25	52.5	79.38	55	91.25

Ppt: Participant [1] Calculated from the mid-point of the duration category chosen as recommended by (Stewart et al., 2001) [2] SUS score range 0-100, ≥68 is seen as above average usability
[3] Ex-SRES, Exercise Self-regulatory Self-Efficacy Score, range 0-100

Table 5.3: Themes and sub-themes identified from the exit interviews

Theme	*Sub-theme*
Personal Context	Pre-existing use of technology Pre-existing goals Pre-existing physical activity
Pedometer	Positive points Negative points
Engagement and Experience of Use	Usability Typical use procedure Setting goals Perceptions of others User experience Accuracy and credibility Recommended changes
Perceptions of changes to walking behaviour	
Perceived influences on walking	Being monitored Self-monitoring Receiving feedback Reviewing goals Using technology (vs. paper) Influences outside of the research project
Continuing self-regulation	

Table 5.4: The ratings given to SMART walks that were completed, and the number of missed and incomplete SMART walks

Participant	*Completed SMART Walks*			*Missed SMART walks*	*Incomplete SMART walks*
	Too Easy	*Just Right*	*Too Much*		
1	11	15	3	2	1
2	5	23	4	0	0
3	1	33	0	3	0
4	2	30	0	16	0
5	0	24	3	2	2
6	0	26	1	5	2
7	4	22	3	3	2

Table 5.5: Mean (SD) daily step counts over the baseline and experimental phases

	Baseline (BL)		*Experimental (Exp)*		*Difference in Mean (Exp-BL)*
Participant	*N (data points)*	*Steps Mean (SD)*	*N (data points)*	*Steps Mean (SD)*	
1	34	1063 (786)	31	3097(1139)	2034
2	33	3510(1692)	32	3503(1082)	-7
3	30	9675(1197)	37	9431(921)	-244
4	34	3833(2460)	48	4778(2858)	945
5	31	3681(1292)	31	3921(1329)	240
6	30	10024(3199)	32	10097(3326)	73
7	32	1987(895)	34	2940(1155)	953

5.1.1 Participant 1

Personal context

A 65 year old female who had been diagnosed with COPD for 15 years, her MRC breathlessness grade was 5 (indicating the most severe level of breathlessness) and she used ambulatory oxygen. Her existing technology use was high, with reported daily use of a computer, mobile phone, tablet, and mp3 player. She had never used a smart phone before. She has osteopenia and has been advised by her GP to walk for 30 minutes a day to protect against osteoporosis. She has a treadmill to help her achieve this. However, despite setting an automated alarm on her computer to remind her to use the treadmill at 2pm every day, she reported having difficulty motivating herself to complete the 30 minutes daily:

> *'There are so many other things I need to do, and I want to do than going walking on a treadmill for half an hour a day'*

She reported being motivated to slow the decline of her illness:

> *'Knowing where the emphysema's going makes it a battle to try and slow it down, because the fitter I am, the idea is the longer I'm going to be able to keep mobile…Because well ultimately I'm going to be sitting in here attached to a machine and the longer I can put that off, the better I feel about it'*

Engagement and Experience of Use

Participant 1 set goals ranging from 6 to 30 minutes (see Figure 5.1), she missed two walks and one walk was incomplete (see Table 5.4).

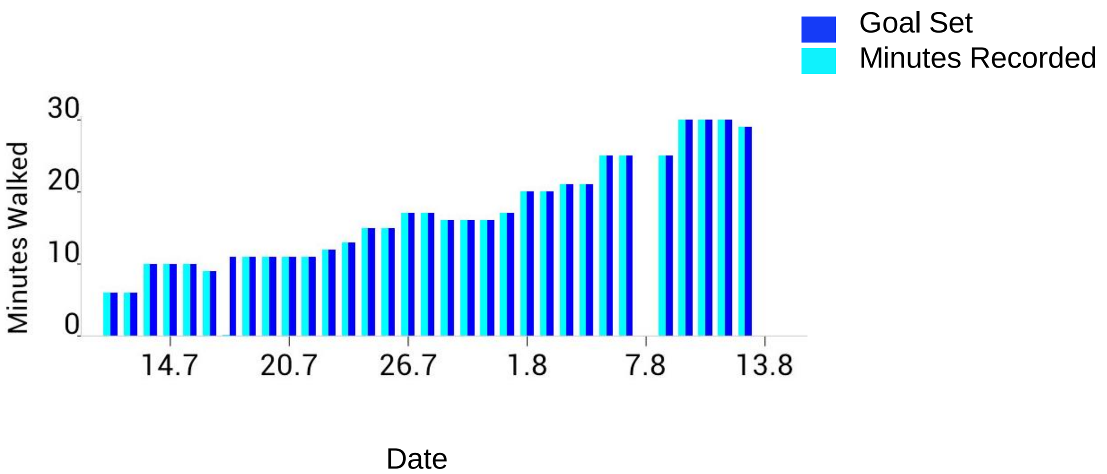

Figure 5.1: Feedback graph showing goals set and minutes walked by Participant 1

The majority of walks were completed on the treadmill. Recently, however, her husband had been away and she had been walking the dog outside. She found this more difficult as it was uphill, she had to carry her oxygen on her back (rather than hanging it on the treadmill) and there weren't handrails to lean on. She sometimes had difficulty scheduling the walks in, and found herself walking at all times of the day. The weather was very warm for part of the experimental phase. This made it harder to breathe and she was aiming to walk earlier in the morning to avoid the hottest time of the day.

> *'A lot of the going backwards [goals being reduced] was because of the heat I just couldn't cope and I had to shorten the walk. What I could have done in retrospect was increased it and just done it in two bits'*

When setting goals the feeling of progress was essential:

> '*It's got to be continual* progress*, I'm always looking for that continual progress or not'*

She chose to put the daily goal up by 5 minutes if it was too easy, and down by 1 minute if it was too hard to ensure this continued progress, but was aware that sometimes she slowed down, or took breaks to reach the target. She wondered whether this might be jeopardising her progress:

> *'I've been looking at time but I've become very aware that I've dropped the speed down so the distance has gone down for the same amount of time and I'm not sure that's improvement, it probably isn't actually, it's probably retrogressive [laugh]'*

To address this she would have liked to have known the distance walked, so she could monitor how this was changing.

> *'You've walked for 20 minutes but you've done 1000 steps and then the next day it's the same target and the same distance but you've done 2000 steps that would be a really nice comparison to be able to make because then the target would perhaps not be so time focussed as step focussed.'*

The mobile device only allows participants to set a goal for tomorrow, following the review of today's walk; this meant that sometimes, when she had rated a walk as 'Too Much' and reduced the time for tomorrow's walk, the next day she completed this, and felt fine to continue. This was related to both how she felt, and the weather.

> *'Setting it, yes, for tomorrow doesn't give much leeway for finding out what today's going to be, you know what the day's going to be like'*

If she noticed the goal had been completed, she would stop walking. On one occasion the phone unexpectedly shut down before a walk was rated (the walk is only registered as completed on the server once the rating is complete), this lost the data and left a blank space on the graph for that day. She was unhappy about this, but was happy that she had noticed that she had completed the walk.

> *'Unhappy. I was just so pleased that I'd noticed and the only reason I noticed was that it was an 11 minute walk and it was 11, 11, 11 and I was just pleased that I'd noticed that, otherwise I wouldn't have had a clue…And it looks as though I didn't do anything at all, and I did'*

Overall she enjoyed using the phone, found it simple to operate, would recommend it to others with COPD and gave it a usability score of 90/100.

> *'It's absolutely brilliant at making you do the exercise, and the only treatment, the only realistic treatment for COPD is exercise, and if you don't do it then you're going to deteriorate and if you've got the system and you make yourself do, then it's going to improve the quality of your life.'*

Behaviour Change

Participant 1 perceived that she had increased her walking during the baseline, as she knew she was being recorded and this made her more aware of her steps, even though she couldn't see the screen of the pedometer. However, she reported being sure she would have walked more with the phone than with the pedometer:

> *'I know it's going to be a heck of a lot more than it was'*

This increase in walking made her feel happy, and she felt it had made her fitter. She spoke about getting to the garage having forgotten to put on her oxygen, whereas previously she would have noticed being short of breath:

> *'Really happy actually, because I know this is what I'm supposed to be doing, erm, for my own health's sake, erm, and anything, anything that makes not just me, but any COPD patients just do, that can't be anything but positive in terms of quality of life, in terms of being able to get out, in terms of, erm, sort of, the NHS and what we cost. It's just great, I mean a couple of times I've actually set off without my oxygen'*

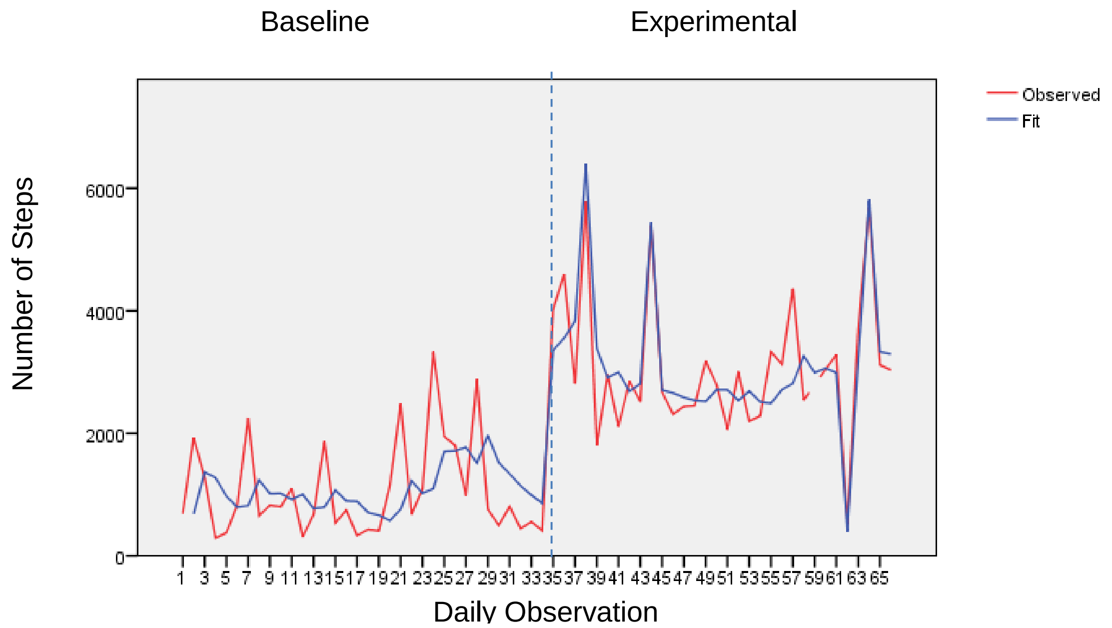

Figure 5.2: Step count and ARIMA model for Participant 1

Her perception of an increase in step count was confirmed by the quantitative data; her mean daily step count between the baseline and experimental phase increased by 2034 steps (see Table 5.5). An ARIMA (1,1,2) model was identified indicating autocorrelation at lag 1, a linear trend and a moving average of 2 deviations (R^2 = 0.73) (see Figure 5.2 for both observed and predicted step counts). Phase was identified as a significant predictor *t* (1) = 4.53, *p*<0.001 with an estimated 2606 more steps in the intervention period (*SE* = 575.34). However, at Lag 18 the Ljung-Box statistic is significant (Q = 40.51, p=0.01) indicating some of the outliers may not have been appropriately modelled and caution should be taken if using this model to forecast.

The reasons given for the change in walking behaviour were initially focussed on social desirability and compliance related to being monitored by someone else, for research:

> *'It's probably I need to do this because it's part of a PhD research and it needs to be completed because I don't want to let her down.'*
>
> *'I think it's just the sheer recording, and knowing that it's going to be monitored. And it isn't even as though I'm going to be held answerable for, you know the day I didn't do anything'*

However, both the baseline and experimental phase were being monitored. The change between the two phases may have been facilitated by self-monitoring and feedback, together with the above mentioned desire to see continual progress:

'The fact that what I've done has been recorded and I can see what I've done and I can see when I didn't do, with that, that gap last week, and there's something physical there to say yeah you're doing Ok, or oops that wasn't terribly good'

There were other influences on Participant 1's walking over this time as she re-joined the gym during the experimental phase. She estimated she had been to the gym 3 or 4 times during the study but perceived the extra walking she had been doing during the study had more of an impact on feeling fitter than the gym:

'Nothing's changed at Breathing Space, the gym I've only just started going back so really it's the extra walking, erm, it is the extra walking and it does make such a difference, it really does.'

5.1.2 Participant 2

Personal context

Participant 2 was a 66 year old male with an MRC breathlessness level of 3 indicating that he felt the statement 'Walk slower than people of the same age on level ground because of breathlessness, or have to stop for breath after about 15 minutes when walking at own pace on level ground' best described his current state. He had been diagnosed for 8 years. His level of technology use was high with daily use of his own smartphone and computer. He reported going for a 5-10 minute walk daily and attending Breathing Space weekly. He reported wanting to attend the Breathing Space gym more often, the cost of membership was given as the barrier to joining an alternative gym. He was aware of the GP referral scheme (which reduces the cost of membership to some gyms for those with COPD) but said:

'You have to get a letter off your Dr to say you, you know you can go or whatever, it's a right rigmarole [laugh]'

Engagement and Experience of Use

Participant 2 set a goal and completed a walk every day. He set a daily goal of 6 minutes and used the phone to record a walk with his dog, around his housing estate. He increased the goal to 15 minutes for the one day per week he was going to Breathing Space, and recorded this walk on the treadmill using the mobile device (see Figure 5.3).

'I just thought, just do the 6 minutes you know and then it's over and done with, you can forget about it then.'

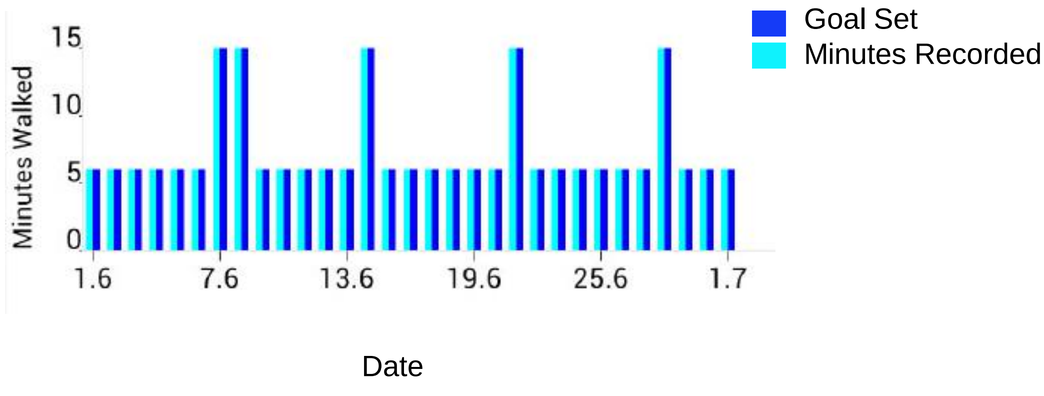

Figure 5.3: Feedback graph showing goals set and minutes walked by Participant 2

He found the phone easy to use and mentioned that it was similar to his own. He rated the phone 100/100 on the SUS. He noticed that the step count varied when he was doing the same 6 minute walk and felt '*cheated'* when he got a lower step count. He reported that the phone was not an accurate record of what he did or wanted to do in terms of walking. He would have liked to have set more than one walk per day:

> *'I think if you can programme it in on the day, you know what the weather's going to be like and you know what you're capable of, you know. So if you wanted to go for a long walk, you could'*

The motivation for this seemed to be to accurately record activity he was already doing:

> *'If I had to, say go up for a loaf or something I could say, another five minutes, walk up there and back'*

Behaviour Change

Participant 2 perceived a change in his walking behaviour when he was using the phone:

> *'I think I did more with the phone'*

He stated he would not have done the daily walk he was doing without the phone:

> *'Yeah it made me go out in the morning and do 6 minutes, I probably wouldn't have done that'*

Phase was not a significant predictor of step count. An ARIMA (0,0,0) model was identified indicating no significant autocorrelation or trends in the data. The Box-Ljung was non-significant (Q = 6.79, p = 0.99) indicating all outliers were appropriately modelled (see Figure

5.4). His mean step count was just 7 steps lower per day in the experimental phase, see Table 5.5.

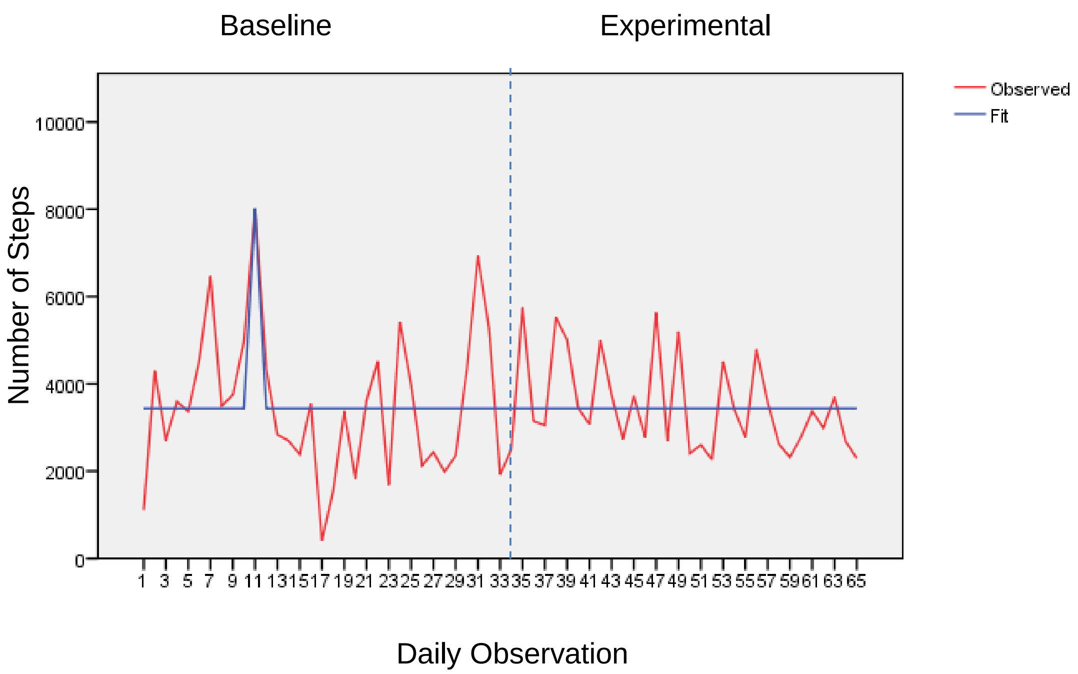

Figure 5.4: Step count and ARIMA model for Participant 2

He reported enjoying seeing the increase in activity on the feedback screen:

> *'I wish I could do that every day'*

However, he was wary of setting the goal too high for the next day, he also thought he would get bored walking around the area and that his dog might not be up to a longer walk:

> *'You were stuck to that 6 minutes so, or if you put 15 minutes it might have been too much and whatever the weather was, or, you know the next day, so you were limited to what you could put into it'*

Although he reported feeling frustrated that he couldn't add additional walks within a day, he still felt the phone had encouraged him:

> *'I just think it makes you do that little bit extra, even if it's a 6 minute walk or a 20 minute walk, you know you might not do it unless you've got a phone there to tap it into [laugh]'*

Although the below statement implies that while he felt the phone did not represent his increased activity, the pedometer would:

'I wish I could have programmed it more and then I could have done loads more on it you know which will show up on the pedometer anyway.'

5.1.3 Participant 3

Personal Context

Participant 3 was a 77 year old male who had been diagnosed with COPD for 6.5 years. He had an MRC breathlessness grade of 1 indicating he is 'not troubled by breathlessness except on strenuous exercise'. His technology use was relatively high with daily use of both a computer and mobile phone. He had not used a smartphone before. He was very physically active, going for a long walk outside daily, and in the years he had been doing this walk he has set himself goals to reduce the number of stops he takes:

'Two years ago, three years ago [doing the walk] we used to have around 5 stops...well now, we'll do it in one stop'

Over the baseline period he walked an average of 9675 steps per day.

Engagement and Experience of Use

Participant 3 missed three walks during the intervention phase, he rated 33/34 walks as 'Just Right' and the final walk as 'Too Easy'. He never changed his goals himself, but did follow the automatic increment of 1 minute following 7 days of rating a walk as 'Just Right' (see Figure 5.5).

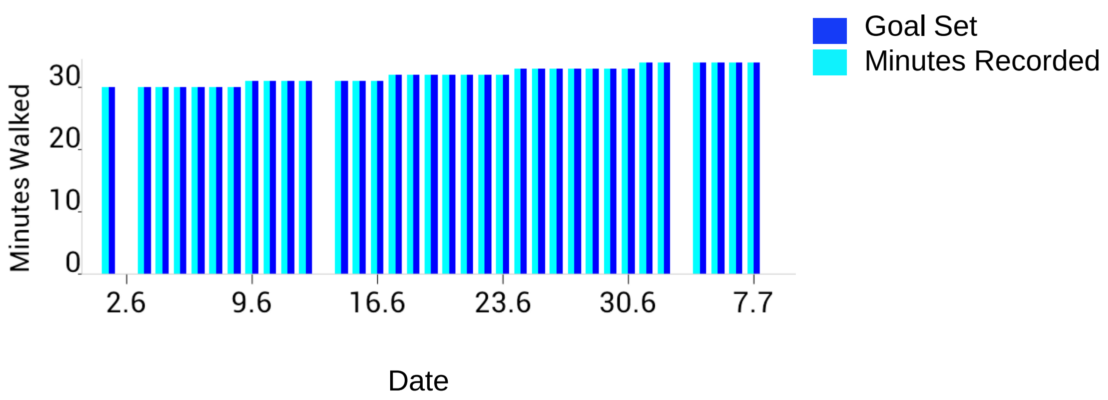

Figure 5.5: Feedback graph showing goals set and minutes walked by Participant 3

He used the phone to record his usual daily walk, he had always completed the goal by the time he was back at the car. He describes the reason he did not alter the goal himself:

> *'Because you can set yourself too high, aye I do and if, the point is, if you flop, it is a failure, you do feel that I didn't do it, I can't do it. No, minute by minute [increment], great'*

Although he said if he was using the mobile device outside of a research project, he would increase the walk more:

> *'You could set your own goals you could, yeah, no, you could make something like it's 35 minutes today, let's do a 40 minute'*

Contrary to his own expectations he found the phone easy to use:

> *'It was simple, if you get somebody of my age and somebody puts something like that in front of you, you think, right can I bleeding use it? But all of a sudden, well it's dead simple'*

However there were occasions he did not press the 'Completed' button and rate the walk, these walks then did not appear on the feedback graph. Participant 3 said he did not mind this as it was recorded on the pedometer, but if he had not had the pedometer he might have minded. Despite this he gave the system the maximum SUS score of 100. He reported wanting more detail about his walking, including pace and uphill and downhill sections. He would also like to have been able to add time onto the walk if he was feeling OK:

> *'You think how did I feel when I finished it? Did I feel fresh? Did I feel completely shattered? Could we have done another 10 minutes?'*

Behaviour Change

Participant 3 reported that despite not being able to see the screen, the pedometer increased his awareness of the walking he was doing:

> *'Yeah, well obviously it did because what it said then was that you erm, you started measuring yourself, do you get what I mean? You couldn't see the pedometer'*

He also reported possibly going for walks when he wouldn't have, had he not been wearing the pedometer, during the baseline period:

> *'There were certain days when I thought, I don't want to do this… well basically, you agreed to do something, and you do it'*

Participant 3 reported not knowing whether he walked any more with the phone, or the pedometer. There was no significant effect of phase and an ARIMA (0,0,0) model was identified indicating no autocorrelation or trends (see Figure 5.6). With a non-significant Box-Ljung (Q =20.34, p = 0.99). His average step count over the experimental phase was 244 steps lower than during the baseline phase.

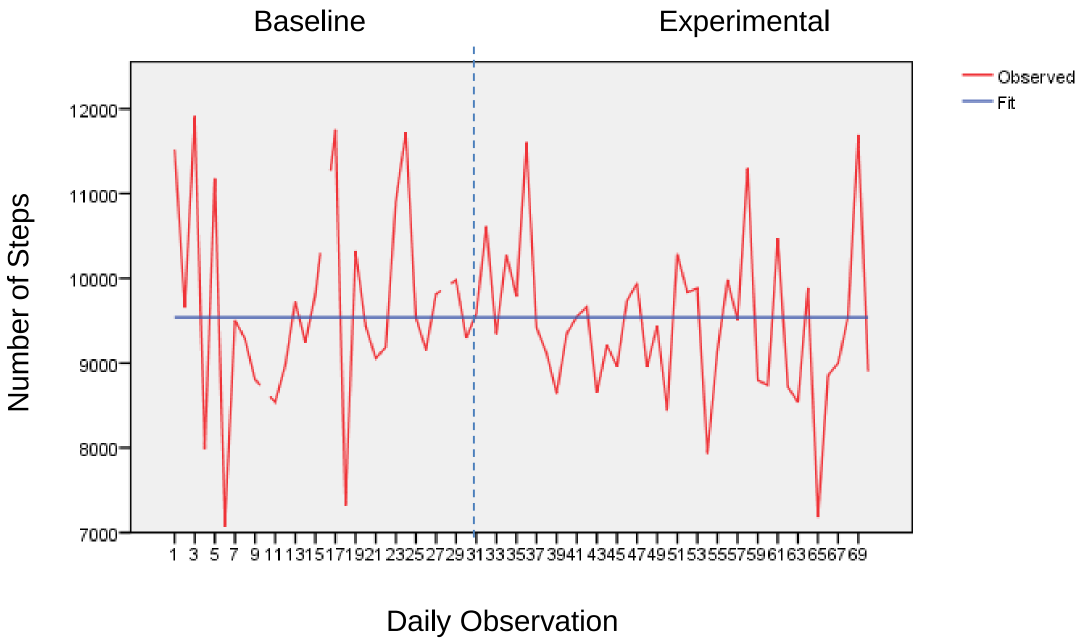

Figure 5.6: Step count and ARIMA model for Participant 3

Participant 3 was keen to follow the program as it was set, so followed the minute increments but was wary of increasing it any further for fear of failing.

> *'Well we didn't, it just put it up by a minute and I thought that's good enough for me. No, I didn't want to go too high, because I'm a clever sod, me, and what will happen is, half an hour? I can do an hour and I usually drop a clanger before that, so I thought leave it up to that, if it's going to be increasing it by a minute every week, that suits me.'*

He was interested in the step counts, and recorded them daily in a paper diary. This indicates a desire for knowledge about his activity and to monitor his activity. When discussing the feedback graphs he indicated they were not an important feature to him by saying:

> *'Well they were just bar graphs, didn't think owt to be quite honest with you. I thought oo look there's a bar graph, there look and it's recording minutes [laugh].'*

When talking about whether the mobile system had any advantage over using a pen and paper he said:

'There's something about it that says if you set it on the mobile that says go and do it, it's as simple as that… I think it's everything that comes into it, the fact that you put it down you've said oh I'll walk for 40 minutes today, go and do it and it's been recorded.'

When he spoke about doing the walk because he has said he will, it is hard to know whether that is to do with being monitored by the thesis author, or his own goal-setting and self-monitoring, he says:

'It's not that you're being compliant it's that you, you think this is what I've agreed to and I'm going to do it'

5.1.4 Participant 4

Personal Context

Participant 4 was a 67 year old male who had been diagnosed with COPD for 5 years. He described himself as 'Not troubled by breathlessness except on strenuous exercise' (MRC grade 1). He reported daily use of a smartphone and computer. He reported that he liked to keep active around the house by gardening, decorating, cleaning etc. He also mentioned that as he enjoyed his time at Breathing Space this has continued to motivate him:

'The feel good factor of being amongst similar sufferers, for want of a better word, and the very pleasant nature of the Breathing Space experience enthused me'

And the importance to him of keeping active was clear:

'So it's all about management of the condition and determination in my case not to let this thing beat me, this condition'

His pre-existing goals were around increasing the incline of his walks at Breathing Space and using his home treadmill more.

Engagement and Experience of Use

Participant 4 was ill during the experimental phase, he reported recovering quickly from this illness. However, this resulted in him missing some walks using the phone. He was keen to make this time up and so the experimental phase was extended to accommodate this. In total he missed 16 walks during the experimental phase, some due to his illness, others due to forgetting or not charging the phone:

'Well I was rather annoyed with myself really because I felt I was messing up the project, and indeed when I was poorly as you know I was concerned that I'd messed or potentially messed up the project by not recording anything for a few days… I just felt silly that not charging it or forgetting it or I've come out without it'

Throughout this time, he continued to wear the pedometer daily. There was only one walk that was started but not completed. He rated two walks as 'Too easy' and the rest as 'Just right'. He started with a 10 minute goal and ended with a 17 minute goal (see Figure 5.7).

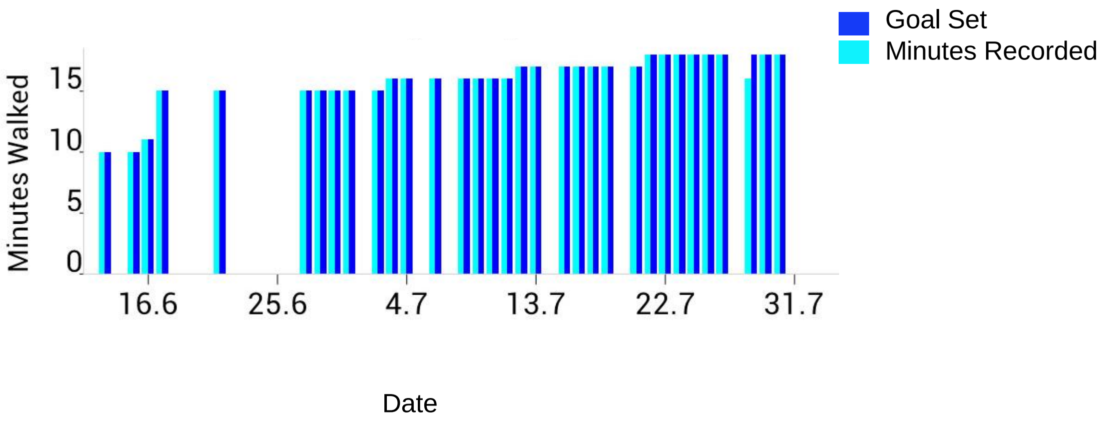

Figure 5.7: Feedback graph showing goals set and minutes walked by Participant 4

He used the phone in his pocket to record everyday activities if he was going to be doing something active. If he had nothing active planned, he would complete the walk on the treadmill. He said he finished the walk unless he was really struggling, and used the pause facility when he used the car. His approach to setting goals was to follow the device:

> *'I took the advice of the machine, the device, and just increased it by the minute or so, as it went along'*

He was very happy to be involved with the project and appreciated the goal setting done by the phone, although he did feel it could have increased more:

> *'I think we started at 10 minutes and I'm now on 18, so that made me feel like I was improving, so the program's automatic nature was an advantage I felt. I think it could push people a bit harder, perhaps it could go up 2 minutes a day'*

Other improvements suggested included seeing how far he was actually walking, rather than it stopping recording when the goal was reached. He felt this might encourage him to increase his goals.

> *'Say if you're walking along Scarborough sea front and your goal was 20 minutes and you actually did 30 minutes, and you think that might make you, if it said what do you want your goal tomorrow to be, you might say oh well 30 minutes because I did that today.'*

Other suggestions were to make the device smaller, or put the program on his own phone and to have a reminder to let him know the walk was paused as he sometimes forgot to re-start it. He also suggested using ambient displays or noises to let you know you have walked over your goal without needing any action from the user, so it wasn't too distracting:

> *'A change in screen colour for example that red is you're doing it and green is my word you're doing ever so well over the top or whatever'*

He also suggested linking other devices such as heart rate monitors to this system to get a more complete picture of how the exercise is affecting his health. He described the phone as easy to use as it was similar to his own, but also similarly to his own, he found the battery life poor. He gave it an SUS score of 90/100. On some occasions he thought he had walked more than the phone had recorded, but he put this down to his walking style rather than the phone; it did not affect his positive opinion of the phone:

> *'I didn't doubt it, if it, if it was doing anything it was telling me I hadn't done as much as I had which must be an advantage therefore [laugh]'*

Behaviour Change

Participant 4 felt he had walked more when using the phone than using the pedometer:

> *'I think I did yeah. I made the effort to do what I'd committed myself to do over and above my general activities.'*

However, although the mean daily step count did increase by 945 per day between the baseline and experimental phases, phase was not identified as a significant predictor of step count in the ARIMA (0,0,1) model (see Figure 5.8). Outliers were identified but appropriately modelled (Q = 8.29, p = 0.96).

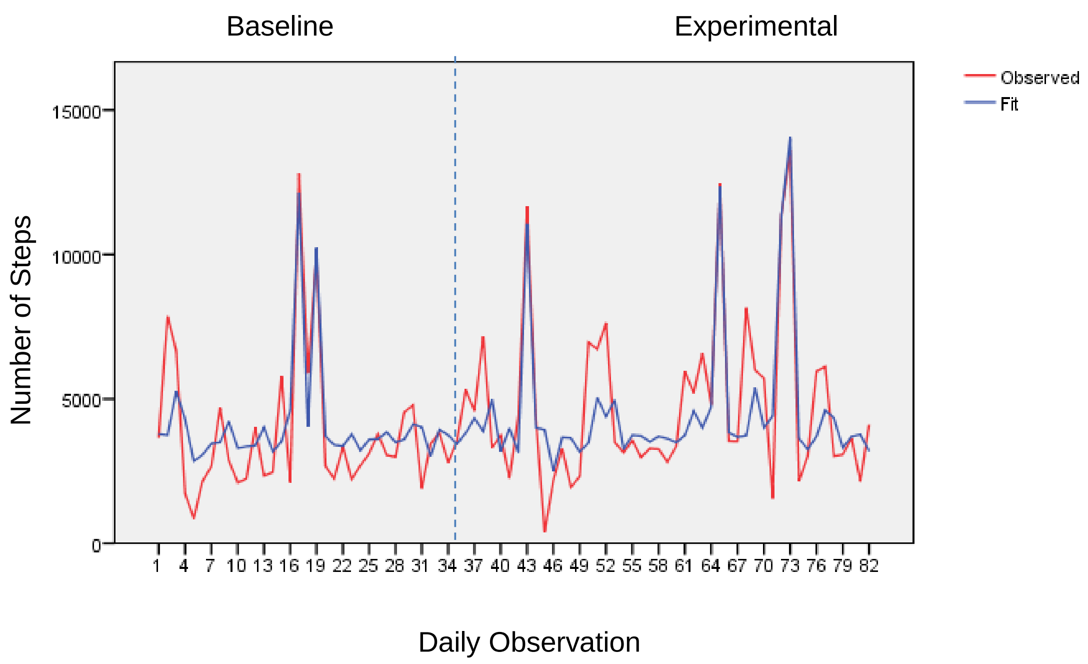

Figure 5.8: Step count and ARIMA model for Participant 4

He reported finding the graphical feedback motivating:

> *'That's what motivates me is to, is seeing the, visually how you're progressing, or if you're not progressing, and then you can do something about it'*

And was keen to complete what he had agreed to do:

> *'The benefit of this thing altogether is that it was something I'd agreed to do and my nature is never to break an agreement so you know you carry on and you do it.'*

He reported finding the device encouraging, and linked using the device to effects on his health:

> *'This device proves to me that yes, it does help encourage me to do more, and I do more, then I feel better and it becomes a self-fulfilling circle and if you sit down and say I'm going to do this when I feel better you'll never do it'*

However, he mentioned that it would be difficult to continue the exercise without this external monitor:

> *'It's going to be more difficult for me when it's gone to do it, because I think well what's the incentive?'*

5.1.5 Participant 5

Personal context

Participant 5 was a 59 year old male, diagnosed with COPD for 11 years with an MRC breathlessness grade of 5. On the questionnaire he indicated using a mobile phone and computer daily but in the interview said his phone was only for emergencies. He had never used a smart phone before. He described being nervous about the amount of walking he could manage when visiting new places:

> *'If you end up going somewhere different, that you don't know, and you've got, you've got to work out how far it is from where you've parked to where you're going to because, as I say, it's not the getting there, it's getting back.'*

He described himself as active, with caring responsibilities for his wife's parents, visiting his daughter, and shopping. He had been in the army for 18 years and recognised the importance of being fit. He attends Breathing Space weekly and makes an effort every three weeks to increase either the time spent walking, or the speed on the treadmill.

> *'About every 3 weeks [laugh]…I crank it up a notch…Just keep going, and keep going, and keep going'*

Engagement and Experience of Use

In the interview Participant 5 said he used the mobile device every day, but the device recorded two missed walks, and two incomplete walks. He started with a goal of 30 minutes, and rated the walks as 'Just Right', when the programme increased the walk by 1 minute (after 7 'Just right' days) he rated the walk as 'Too Much' and reset it to 30 minutes (see Figure 5.9).

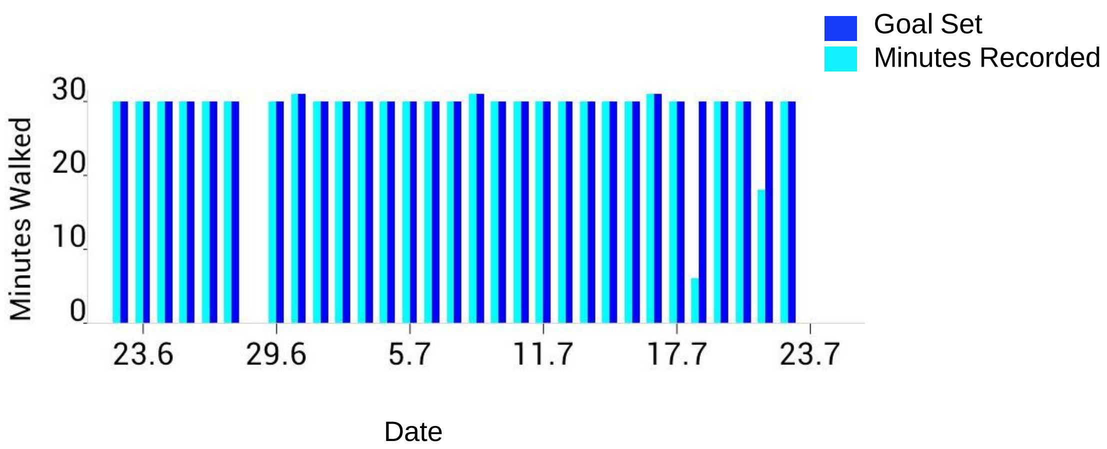

Figure 5.9: Feedback graph showing goals set and minutes walked by Participant 5

He used the phone to record his every day activities, pausing it when he got into the car between each errand. Once a week he recorded his walk on the treadmill at Breathing Space. He described that if the phone had registered all his activity in a day, he might have used this information to increase the amount he was doing:

> *'Ok so I've managed to walk for an hour and a half, how do I feel? Am I tired? Exhausted? Er, do I need to go to sleep? You know because some days I get so tired I just get down again, did the weather have anything to do with it? You know, that sort of thing, you know, I've got to work out and then say right yeah, can I keep doing that? You know to improve myself? You know?'*

However, this seemed to be more to do with monitoring his existing levels of activity than setting goals above his current level of activity. He was interested in recording what he did in a day, but when it was suggested in the interview that he could have increased the goal time he responded:

> *'Yeah, but I might not have reached it [laugh]'*

He described the phone as easy to use:

> *'I mean it was simple enough it's not, I mean it's not rocket science'*

Although he did complain that it was difficult to turn off (rather than just put to sleep) and that sometimes it did not seem to record accurately. He reported being uncertain whether the phone was inaccurately recording, or he was spending less time walking than he had thought:

> *'If it's accurate it's shown me that maybe some days I'm not doing as much as I think I am, you know?'*

He gave the system a below average usability score of 55/100 on the SUS.

Behaviour Change

Participant 5 did not try to increase his activity, and thought he walked exactly the same amount throughout the research:

> *'No, I didn't see the point in doing anything silly, and saying right I'm going out and I'm going to go and do loads and loads of walking today, you know, just because I'm wearing that…if you can't keep it up, you know what I mean, so I just did normal every day activities'*

Phase was not a significant predictor of step count in the ARIMA (0,0,0) model Q =26.41, p = 0.09 (see Figure 5.10).

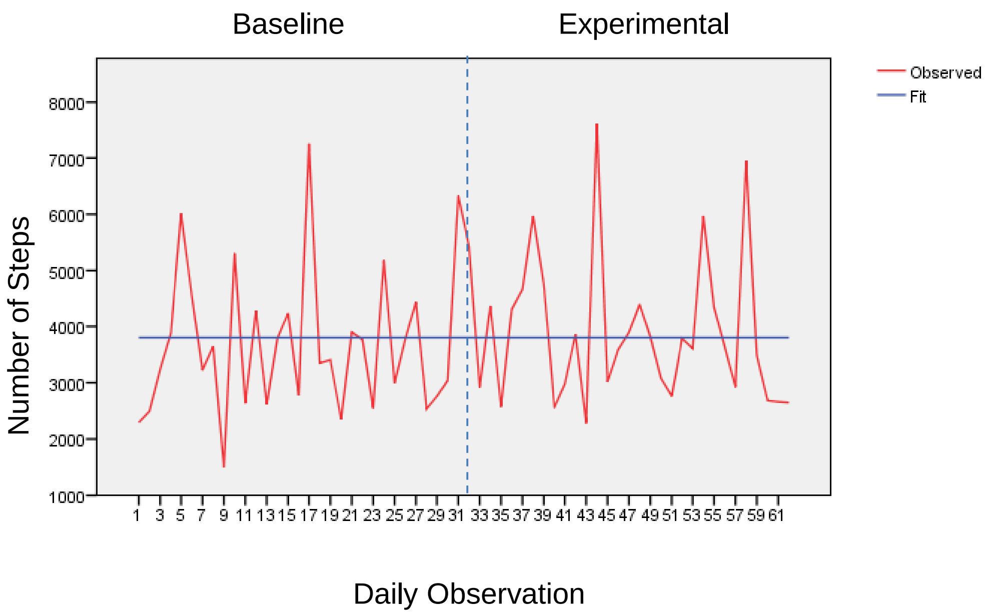

Figure 5.10: Step count and ARIMA model for Participant 5

He did report looking at the progress screen and that was how he noticed he had missed a day. He also seemed to emphasise the importance of being monitored and getting an accurate representation of the activity you are doing:

> *'If you monitor yourself, it's too easy to turn round and say ah I'll not bother today, you know I'll do a bit more tomorrow or whatever, and if it's only you that's monitoring it, you may tend to slack off a bit, if you've got an outside monitoring system you tend to be more aware of it and therefore do a little bit more to keep up with certain goals.'*

The perceived accuracy was clearly a problem to Participant 5; on the one hand he complained it was not accurate:

> *'On a Saturday morning I go to the supermarket and it normally takes me an hour to walk round the supermarket and most times the phone had only registered something between 12 to 17 minutes'*

On the other hand this was used as a reason the phone was better than paper:

> *'So to write things down on paper, it's like this supermarket thing, you're going round the supermarket and you're in there for an hour but the phone's only registering 12, 17 minutes, so if you're just writing down on a piece of paper, you're not getting a true reflection'*

Participant 5 indicated that he did not feel he had the time to fit any more physical activity into his daily life. However, he would have liked to have seen how much he was doing at present, and thought that someone else monitoring it was a good idea, as then he could be alerted in case his usual level fell.

5.1.6 Participant 6

Personal context

Participant 6 was a 69 year old female who had been diagnosed with COPD for 7 months. She described her current condition as 'Short of breath when hurrying on a level or walking up a slight hill' corresponding to an MRC breathlessness grade of 2. She described herself as:

> *'Hopeless with technology, absolutely hopeless'*

The only reason she owned a mobile phone was in case she broke down in the car, she never used it otherwise and had never used a smartphone. She used a computer about once a week. She was physically active, attending Breathing Space once a week, tending an allotment, walking her dog daily and going for longer 3-5 mile walks every two weeks. She was visiting a health trainer throughout the intervention (baseline and experimental phases). She was referred to the health trainer by her GP as she was trying to lose weight. The trainer had worked with her to look at her lifestyle holistically in terms of diet, exercise and other activities. He had encouraged her to start thinking about what to do when her maintenance sessions at Breathing Space end, and given her leaflets about Tai Chi and other local activities. She also reported applying to the GP referral scheme to get discounted sessions at a council gym. When she sets goals for herself at Breathing Space, she looks at what she has done previously on the record card then tries to increase the time spent walking or the incline on the treadmill.

Engagement and Experience of Use

Participant 6 rang the researcher four days into the experimental phase to say the mobile device was showing her screens she didn't recognise. She was talked through pressing the home button and turning the device off and on again, but she could only lock and unlock it. The researcher visited the same day and the phone had run out of battery, and when the phone had charged up, it had reset to the home screen. The researcher ran through turning it off and on, using the instruction manual as a guide, and what to do if the problem happened again. There were no further technical problems for the remainder of the experimental phase. However, she did sprain her ankle, and was walking very little for 4 or 5 days. She missed 5 walks during the experimental phase and did not complete 2 of the walks. The missed walks were due to forgetting the mobile device, attending a funeral, and her sprained ankle. She was offered the option to extend the experimental phase to take the missed walks into account and declined. She started with a goal of 20 minutes which she rated as ‘Too Much’ and reduced to 19 minutes, following this she rated all the walks as ‘Just Right’ so the automatic increment resulted in a 22 minute goal by the end of the phase (see Figure 5.11).

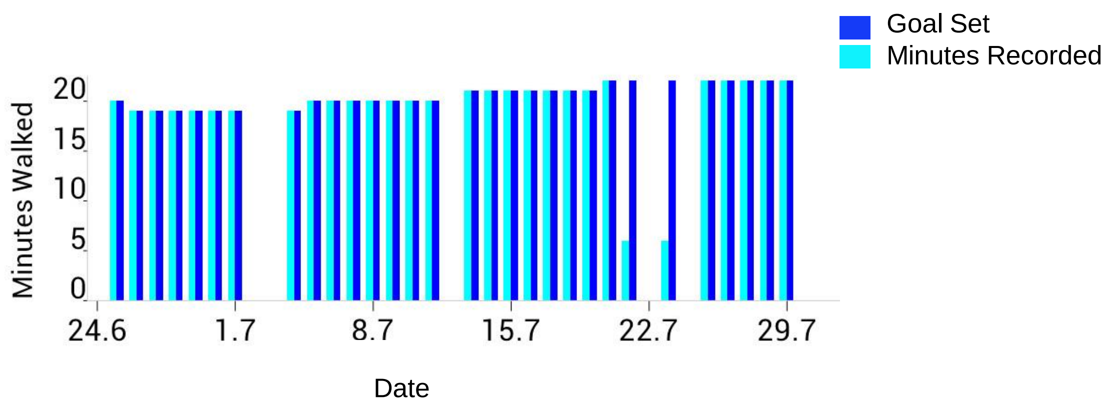

Figure 5.11: Feedback graph showing goals set and minutes walked by Participant 6

Participant 6 completed the walk either with her dog, or kept the phone in her pocket while she was doing everyday activities. She described the phone as difficult to use, she found it hard to switch off and awkward to take with her. She gave the phone the lowest SUS of the participants at 45/100:

> *‘Having to think how am I going to carry this smartphone, which erm, I was scared of dropping it, I, I didn't like it, I’m quite relieved that the 4 weeks of using that are over’*

She found the goal easier to reach when she was doing everyday activities rather than going for a specific walk:

> *‘I was surprised at how quickly it got to 22 [minutes] when I wasn't kind of looking at it’*

There were times when she was walking the dog that she was unsure of the accuracy of the recording, but thought it might be because she was not walking for the whole time she was out:

> *‘I’m far more aware now that if the dog has stopped, because he's very slow, and I realise he's not close behind me, I walk back to him I don't stand there and wait for him which I would do before I had the smartphone. I didn't do that with the pedometer, I didn't have to do that with the pedometer but I was thinking you know I’m never going to do my 22 minutes if, according to this thing’*

She suggested that both weekly recording and displaying activity that exceeded the goal would be useful changes that could be made:

> *'I was about 2/3 of the way round when it went off so I know I did more than 22 minutes, but it would have been nice to have recorded that. It would have recorded it on the pedometer.'*

Behaviour Change

Participant 6 thought she had walked a bit more with the phone:

> *'I was more aware of how much I was expected or needed to walk with the phone. So, I probably walked a bit more with the phone than I did with the pedometer, erm, this setting goals is, is a good thing really.'*

Her mean daily step count increased by only 73 steps from the baseline to the experimental phase, however, this would have been negatively affected by her spraining her ankle as no extra days were added. There was no significant effect of phase in the ARIMA (0,0,0) model Q = 26.49, p = 0.09 (see Figure 5.12).

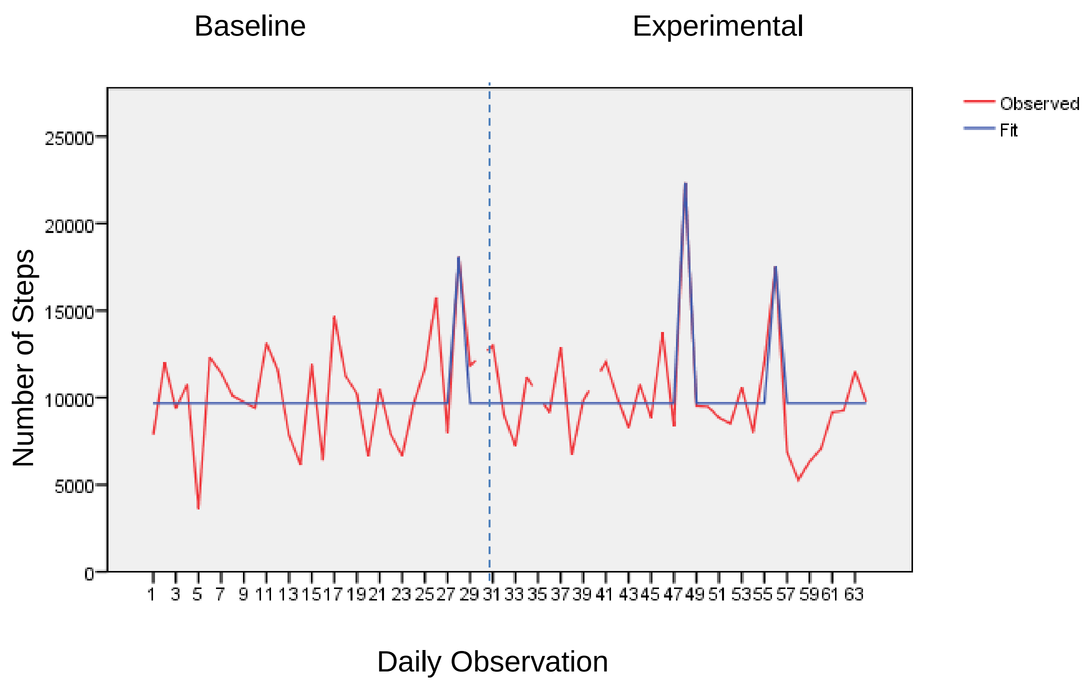

Figure 5.12: Step count and ARIMA model for Participant 6

So although she found using the phone frustrating she did feel it had been good:

> *'Sometimes a bit, oh gosh I haven't done my 22 minutes today, I've got to go out and do it, erm, but I do know walking is good for me I do know that I should be doing it.'*

At times she felt achieving the goal was frustrating:

‘It frustrated me quite a lot really and that's when I’d extend the walk further than I’d normally go erm, just to make sure I’d done the correct amount of time. But then I didn't say it was too much. Because it wasn't too much for me, it was too much for the sort of, my usual routine pattern.’

But she also described finding the goal-setting useful:

‘I think it was the target setting that was helpful for me’

She described not finding the goals set ‘realistic’ as they did not challenge her. She suggested it potentially being more useful to set weekly targets, as day to day her activity will fluctuate, but she would be interested in seeing whether over a week her activity was roughly equivalent:

‘I often did more than [the target time], so, but I didn't want to be curtailed into having to do that, you know I didn't want to have a goal that said ok you did 45 today, therefore we'll do 45 again tomorrow, I didn't want that, but cumulatively over the week’

One of the problems she had was that it was very warm weather over the experimental phase, and her dog is elderly and did not want to walk. She describes how she does not enjoy walking on her own.

‘But walking on your own without a dog, and without another person, you know I’m not a shopper, so I don't, you know, walk to look in shop windows. And I don't particularly like walking, even just walking round the village very much, I’d rather go out into the fields. Erm, I think that could be a future problem for me, if I have neither a dog nor [my friend] to walk with.’

She did not view the feedback screen often as she felt she didn’t need to:

‘Occasionally, not a lot because I knew that , if I’d done 19 or 20 or 21 and it was a daily, apart from when I sprained my ankle, and when I forgot it when I was [at the funeral], erm, it was a daily activity, yup, so I didn't often view [the feedback graph]’

She described that she did not need to look at the feedback graphs to know what she had done, indicating an element of self-monitoring, rather than purely due to her being monitored:

‘I know I’m doing it for your research project but also it's for my benefit as well isn't it? It’s to make sure I am exercising, or hoping, yeah it is, and I know whether I’m exercised or not [laugh].’

Although she followed the goals as they were set by the phone, she would not have set her goals to increase, the length of the walks she undertook being decided by other factors:

> *'I don't think I'd have increased it, because I, I don't know, because usually I was taking it with the dog, although not with the hot weather. Erm it, in a way, it's almost the dog that sets the length of walk but because according to the phone I hadn't done the amount of time I was supposed to have done then we extended the walk. Erm, so, I did feel that I was being judged by the phone [laugh]. But that wasn't a bad thing, that was not a bad thing. It can't do any harm to do more exercise rather than less you know? I wasn't coming home exhausted you know saying that damn pedometer, that damn phone it made me do this [laugh]'*

She did think the phone held advantages over setting goals on paper, because it is easy to cheat a paper based system:

> *'Well to be honest, a piece of paper and you've only done 16 minutes you're not going to necessarily say that are you? It is supposed to be an accurate record of, I mean technology doesn't lie.'*

Participant 6 summed up her experience with the phone thusly:

> *'Although I found it cumbersome and annoying, it, overall I would say it was a good thing to have'*

5.1.7 Participant 7

Personal Context

Participant 7 was a 71 year old female, diagnosed with COPD for 3 years and was MRC grade 3 at the time of the intervention which is defined as 'Walk slower than people of the same age on level ground because of breathlessness, or have to stop for breath after about 15 minutes when walking at own pace on level ground'. She describes herself as happy with computers, though not that interested in them, using them less than once a week. She uses a mobile phone every day, although had never used a smartphone before. She described walking frequently with her husband. She was attending Breathing Space and describes doing what she is able to do each time, depending on how she is feeling.

> *'You do what you feel capable of doing that day, whereas if you're not very well you don't'*

She was attending a weight loss class at Breathing Space as well as the rehabilitation maintenance class and was hoping in the future to join her neighbours at an aerobics class specifically for mature residents in the area.

Engagement and Experience of Use

Over the course of the experimental phase Participant 7 missed 3 walks and did not complete 2. She started with a goal of 10 minutes, doubled this to 20, then increased it again to 30 minutes. She twice achieved a goal of 45 minutes, but found this was too much, and reduced to finish with a goal of 40 minutes (see Figure 5.13). She decided on the next day's goal depending on what her and her husband had planned. If she knew they were not going to be very active, she rated today's walk as 'Too much'. If she knew they were going to be very active, she rated today's walk as 'Too Easy'. When she did not complete walks this was due to a change in plans resulting in less activity than she had been expecting. She reported feeling unhappy seeing the unfinished goals on her progress graph:

> *'Miserable [laugh] because I'd not achieved what I wanted to do, but it was just a coincidence, that er, had it been set in the morning it wouldn't have happened, I would have probably put 20 minutes.'*

Her strategy to avoid this feeling was to alter her goal downwards, as she reported being unable to fit in the extra activity.

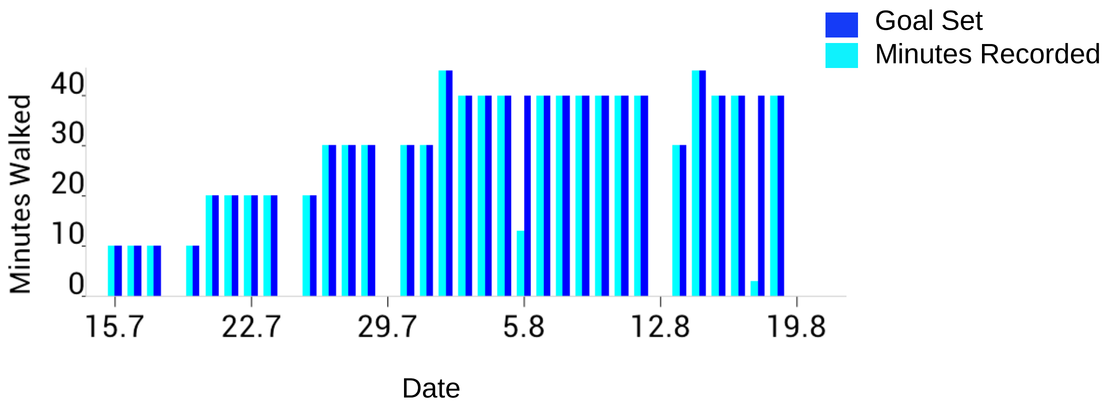

Figure 5.13: Feedback graph showing goals and minutes walked by Participant 7

She found using the phone frustrating as she reported it did not register her steps accurately as she was walking:

> *'We timed ourselves one day, because I said, I said to [my husband] it's not working properly this. When we went for a walk and we were on a walk, we weren't shopping, we were on a walk, we both looked at our watches and set off*

at a certain time and walked round to the first seat where we normally sit and we knew how far we'd walked and it just wasn't nothing like what was on there at all'

On one occasion the review screen was not shown after she had pressed completed, this resulted in the walk not being stored on the feedback graph. These accuracy problems made her feel frustrated:

'As though I wanted to throw it in the river, throw it away, I did carry on using it, but I've not much confidence in it.'

She had several recommendations for improvements to the system including making it smaller:

'Something a bit smaller for a lady to carry'

Setting a goal in the morning, instead of the night before:

'I think you're better off setting it in the morning. You never know how you're going to feel the next day, and you're never going to know what you're going to do'

She felt some screens and options were unnecessary, such as being able to view your progress when you pause the walk and the initial screens:

'You start your walk, you set your time up don't you, then it says start, then it asks you to continue, do you want to continue? Yes, then about illness if you're ill don't do it blah blah blah which I suppose is a warning really for people isn't it? But it just seemed to [be] press yes, yes, yes, or go, go, go, start, until you actually started the thing'

She rated the overall usability a below average 52.5/100. She reported finding the phone difficult to switch off, that it lost power too quickly, was opening programs she didn't expect and she was being contacted by Tesco (who provided the data contract):

'Sometimes when you pressed it on it came up with a face there and it kept saying add contacts'

'I switched on one day and it was Tesco, it said I've got to pay £5 something or other to top up and I thought oh golly, just ignore it'

She did report liking the weather report however (this was a standard feature on the HTC phone used, not part of the study software):

'One thing I did like about it…it tells you the weather wherever you are which is really good, it comes up there [shows the interviewer], Rotherham, partly sunny. We even went down to a little place called Chapel St Ened's and it came up with that and I couldn't believe it'

Despite the usability problems and her frustration with the accuracy, Participant 7 reported that she enjoyed using the phone:

> *'It was frustrating at times but I didn't give up on it, I carried on with it, I persevered with it and I beat it at its own game, because I walked more than it said [laugh]…I beat the machine!'*

And that looking at the feedback graph encouraged her:

> *'I feel as though it has helped me, it's given me that extra incentive to what I would normally have had because you can see what you've achieved'*

Behaviour Change

Participant 7 felt she had walked more during the experimental phase but acknowledged that she had a chest infection during the baseline phase, and this would have negatively affected her step count during that phase:

> *'I had a really bad chest infection so perhaps I didn't walk as far as what I have done the second time. This last month I seemed to have walked miles, well I know we've walked a lot'*

She identified a number of potential influences on her walking behaviour over the course of the intervention:

> *'[During the baseline phase] I think I'm more aware of it, this past month we have walked more, but we've walked more not because with the pedometer but because I've been told to walk more to get the lungs working better…By Breathing Space you see, to get plenty of exercise, get as much walking in as I can. So it just happened that I've got a pedometer as well that you think oh right you know I've got that, I got the miles up and then of course with the [mobile device] you think, well, I've got to achieve that and you know, even if you're crawling you want that little flower to be full and not part full'*

Her mean daily step count increased by 953 steps from the baseline phase to the experimental phase. However, this increase did not result in a significant effect of phase in the ARIMA (0,1,1) model identified (see Figure 5.14). The ARIMA model indicated a linear trend within the data and the non-significant Box-Ljung test indicates outliers were modelled appropriately (Q =20.01, p = 0.27).

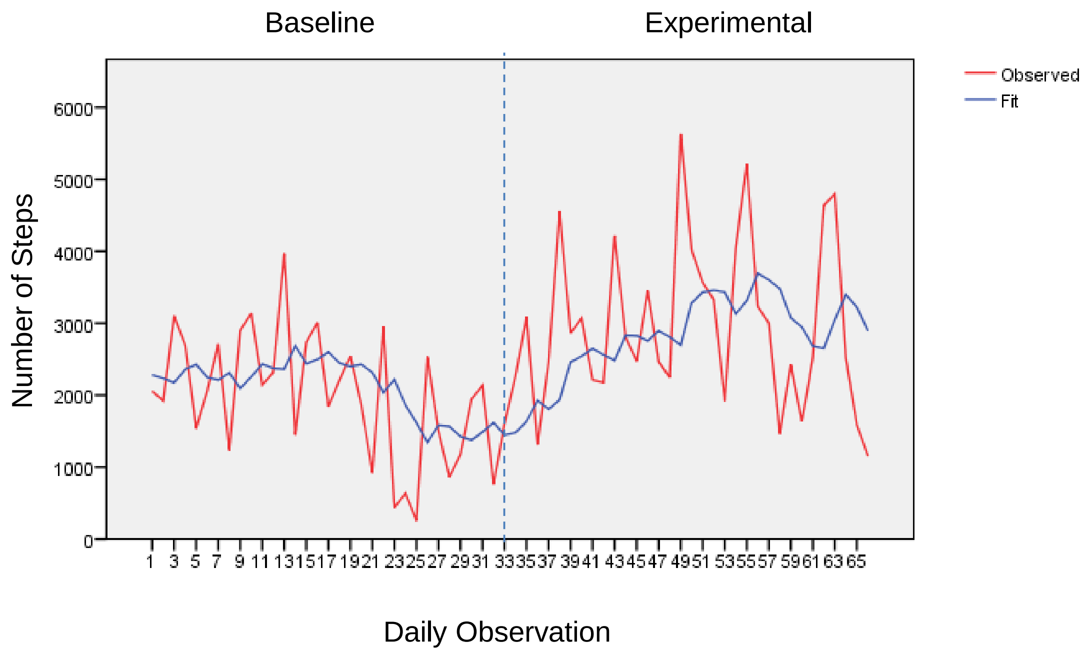

Figure 5.14: Step count and ARIMA model for Participant 7

Looking at the feedback graph was important to Participant 7 to judge whether she was on track:

> *'You can look back and see that day I failed, that day I've won'*

Although she felt viewing 30 days of activity was not necessary:

> *'I think a 7 day graph is enough because you're not bothered about the 30 because does it matter what's happened in the last month? It's only what's happened in this last week really isn't it?'*

She was keen to stress that the graphs were not an accurate depiction of her and her husband's activity:

> *'We walked for a lot more than what's on those machines'*

She described trying to set her goal to reflect their walking, but also take into account her doubts about the accuracy of the recording:

> *'Because I didn't feel that 20 minutes was enough and I knew that we were going to be busy walking, and I did think about putting an hour but I thought the way it was going I might have to walk 4 hours for it to register an hour you see'*

Participant 7 reported that setting the goal and seeing her progress were important:

'I think to me it was an incentive to er, to get the walking in and to prove that you'd done it'

She had doubts about her ability to continue regular activity in the future, but overall felt that the phone had done her, and her husband, good:

'Because you don't know do you? Whether you're going to carry on doing it, you're hopeful you are, but whether you've not got that spurring on in your hand that you want to throw through the window, and you think it's there it's telling me I've got to walk 40 minutes and I'm only on 27 [sigh] I'll do the other 13 in a bit. You know you look at it and think no I've got to do 13 more minutes, may as well do them now get them over and done with. You know so you don't know. I hope it does, I hope it does keep us, because it's kept [my husband] going as well as me'

5.2 Discussion

The findings presented in this chapter show that despite some participants giving the device a less than average usability score, people with COPD had minimal problems using the device daily. They used it to set goals, review goals, record activity and view feedback. Elements of the system were well received, with all participants appreciating the objective measurement of activity, and some reacting positively to having goals set by the mobile device, and receiving feedback. However, although five participants increased their average daily step count (three by over 900 steps) only one participant significantly changed their walking level while using the mobile. This was not a problem of converting goals into action; the majority of the time the goals set were achieved, but this achievement was not sufficient to show a significant change in behaviour over and above the daily variability across both time periods in six of the seven *N*-of-1 studies. The reasons for this change or lack of change are complex and individual, and their discussion is split into three sections: a discussion of the technological factors and psychological factors that might lie behind the individual's change or lack of change; and a discussion of the impact the methodological decisions taken may have had on these results. These will be followed by a conclusion that outlines the future directions that could be taken from this research.

5.2.1 Technology factors

Participants used the mobile device daily and achieved the walks that were set in the vast majority of cases. The BCI was made up of both persuasive technology techniques: tunnelling, tailoring, self-monitoring, praise and liking, as well as expertise, surface credibility and 3rd party endorsements to increase credibility: and BCTs derived from control theory; self-monitoring of activity, specific goal setting and receiving feedback. Participants were asked if there would be any difference between the mobile device and a paper based system. Their responses suggested that the fact the intervention was delivered using technology did have some role in making activity more likely. However, although the goals were tailored, some people did not see the goals as reflecting their levels of activity, or being appropriate for them. There was also a problem reported with the tunnelling, where some participants did not realise they had to press ‘Completed’. The text on the button could perhaps be changed to ‘review’ or ‘press to review’ to lead people through to the next screen. From the interview data, the praise elements were less important than the feedback graph for making users feel good about their achievements. Some users reported wanting to beat the mobile device, or *having* to do what the device *told* them to, these types of responses indicate the device might have been given the role of a social actor by some participants (Fogg, 2003). As discussed in Chapter 1, developers are now looking beyond usability to user experience. Participants in this study reported enjoying using the technology and feeling triumphant and determined, but also feeling frustrated and cheated at times due to: perceived inaccuracy, the feeling they *had* to do something they didn’t want to, or the perceived lack of fit between their activity and feedback they received. Potentially, alternative dialogue support techniques might be used to direct the interaction with the technology to ensure negative feelings are minimised.

There were concerns around the accuracy of the recording. The response to this varied from having no effect, to creating uncertainty about whether to trust the phone, or their own perceptions of their activity. As there is no ability to cross reference from the pedometer to the mobile device, it is also unclear to the researcher what the cause of the perceived inaccuracy was. Credibility is recognised as an important component of persuasive technologies (Oinas-Kukkonen & Harjumaa, 2009), and in the future this would need to be ensured either through a joint calibration process, so the user could see how their activity affects the feedback received, or an initial set-up to increase the sensitivity of the step counter program to ensure each step was being recorded.

It has been argued that use of technology in older adults is less influenced by attitude towards the technology than it is in younger adults (Renaud & van Biljon, 2008). It has been noted that while many models of technology acceptance assume the final point to be either acceptance or rejection, for many older adults they remain between these two states, for example using only some of the features. This enables older adults to continue using technology for a limited range of tasks, without fully accepting it (Gelderblom, van Dyk, & van Biljon, 2010). In this case, participants were given the technology to use as part of a research study. Their engagement and use therefore may have been less motivated by factors intrinsic to the mobile device, such as perceived usability, and ease of use, and more motivated by factors extrinsic to the device itself such as social desirability, commitment to the research, and the credibility bestowed on the device by being associated with the University. This might explain why participants were happy to engage in aspects such as recording walks, but very few engaged in pro-active goal setting, preferring to follow what was seen as the plan set by the mobile device. There is some support for this explanation in that six of the seven participants indicated that the fact a researcher was going to look at the results was motivating. However, four participants said they would keep the mobile outside of a research project, which could indicate a level of acceptance based on the device itself.

Only two of the seven participants were familiar with touchscreen mobile devices and it has been suggested that to expect behaviour change in addition to using an unfamiliar device is an unrealistic aim for persuasive technology (Fogg, 2009c). Although this may have had an effect on how people felt about the mobile device, and how difficult they thought it was to use, unfamiliar hardware is not thought to have influenced these results. All participants used the mobile device daily, with only one occasion when technical assistance was called for. However, the choice of technology channel should be considered further. Participants appreciated the automatic nature of the mobile device, and the goal setting and feedback features. However some indicated they would not want to carry it around all the time. This makes this device appropriate for monitoring activity for a finite amount of time, to reach a goal for example, but not ideal for measuring general levels of physical activity. For this, a pedometer might be more appropriate. However, devices that are simpler and easier to carry around, often have a reduced capability to offer feedback and interaction. This could be addressed by a combination of hardware devices such as a pedometer and phone that communicate through Bluetooth. This could be considered in future research.

5.2.2 **Psychological factors**

Recruiting people who had completed a pulmonary rehabilitation course and were attending maintenance ensured a certain initial level of motivation and an intention to stay physically active. However, the link between the intention and the specific goals set might not have been strong enough. At the first meeting, participants were asked to set their initial walking goal (the researcher had a suggested maximum goal time that was provided by the lead physiotherapist); the initial goal was set to the lower of the two times. Most participants were conservative in their initial goal and, although participants were encouraged to increase their goals over the time (both verbally and in the instruction manual), the safety element was also emphasised, to ensure participants did not push themselves too far. This concern for safety is especially important when working with a chronic illness population, however this may have meant that participants did not form a strong enough intention to increase the time they spent walking, keeping instead a very general intention to keep active.

A conservative initial goal also meant participants were achieving it immediately; and the discrepancy between current behaviour and desired behaviour thought to motivate change was not present (Carver & Scheier, 1982; Moskowitz, 2012). If the intention and the goals were closely linked, and the initial goal was below their intended amount, there would still be a discrepancy between current activity and desired activity, and this may encourage users to set increasing goals (referred to as 'discrepancy production') until they fulfil their broader intention (Scherbaum & Vancouver, 2010). This could be what occurred with Participant 1, who had a pre-existing intention to reach 30 minutes walking, and an initial goal of six minutes. However, for the other participants, without the close link between the intention and the specific goal, achieving the goal might have felt like an end point in itself, as there would be no discrepancy and therefore no motivation to increase the goal. Whether to set goals that are achievable or ambitious is a debate currently active in neurological rehabilitation (Playford, Siegert, Levack, & Freeman, 2009). There could be emotional consequences in rejecting an ambitious goal to choose one that is achievable, but similarly, if the goal set is thought to be unachievable, this can prevent someone striving towards it. The solution proposed by Playford et al., was to set long-term goals that were ambitious, but ensure objectives were in place to reach these long-term goals with achievable specific targets set to meet the objectives. This combination of over-arching goals, objectives and specific targets may help support the person's confidence, while encouraging them to continue striving.

Participants in the current study mentioned they would have liked to have seen a more realistic estimate of their activity by showing activity over and above the goal amount (currently the feedback graph only shows activity up to the goal). This again would have introduced discrepancy, by showing how much more activity they were doing than their current goal. The interview data indicates this might have encouraged some to increase their goal. By only displaying the activity up to the goal being reached, the researchers may inadvertently have been denying participants credit for the activity that they had performed, and this can negatively affect people's opinions of persuasive technology to increase physical activity (Consolvo, Everitt, & Smith, 2006).

An alternative theory of discrepancy production involves people becoming more confident in their activity, with increasing self-efficacy in the situation leading the individual to challenge themselves (Bandura, 1991). There is some support for this hypothesis in the current data as the two participants who altered the goals most themselves during the course of the experimental phase (participants 1 and 7) were the only two participants with higher exercise related self-efficacy post experimental, than pre-baseline. However, caution should be taken when interpreting the Ex-SRES results as they could be subject to measurement error. It is unclear why six of the seven participants would decline in self-efficacy during the baseline period. It could be speculated that they became more aware of their physical activity while wearing the blinded pedometer, and this awareness led them to recognise situations in which they found walking difficult. The goals set in the experimental phase were easily achievable by most of the participants, and this could have contributed to the increase in self-efficacy during this phase. However for two participants, there was a decline in self-efficacy during the experimental phase. The effect of this type of intervention on self-efficacy should be investigated in future research, either through using the scores to prompt discussion in the exit interview, or looking at a larger sample to see if statistically significant changes can be seen.

Low self-efficacy has been found to be associated with depression (Bandura and Locke, 2003) and PwCOPD are known to have high rates of anxiety and depression (Zhang et al., 2011), this could therefore also affect an individual's ability to engage in discrepancy production. In addition, lower mood could also influence a participant's ability to remain engaged with an intervention. A recent trial of self-management education (with no physical activity component) found that those who dropped out were more likely to have higher anxiety and depression scores (Bucknall, Miller, Lloyd, Cleland, McCluskey, Cotton et al., 2012). However, the same trial split those who completed the intervention into successful self-managers, and others; surprisingly, successful self-managers were found to have higher baseline scores on the Hospital Anxiety and Depression Scale (HADS, Zigmond and Snaith, 1983), indicating lower mood. The self-management intervention improved levels of anxiety in PwCOPD, but did not have an effect on either depression or self-efficacy. As previously noted, it has been found that physical activity can improve both self-efficacy and depression in PwCOPD (Coventry et al., 2013; Scherer, Schmiedel and Shimmel, 1998). There are therefore unanswered questions relating to the relationship between self-efficacy, physical activity and affective state. These could be further explored by including a measure such as the HADS (Zigmond and Snaith, 1983) to assess both baseline levels and any changes over the course of an intervention.

It has been found that, although pulmonary rehabilitation improved self-efficacy levels, initial self-efficacy (COPD related, rather than exercise related) does not predict goal attainment post-rehabilitation (Garrod, Marshall, & Jones, 2008). The goals set in this case focussed on meaningful and realistic goals to strive for such as 'I want to be able to walk to corner shop at same speed as husband and continue a conversation' (Garrod et al., 2008, p.792). Typically in rehabilitation, once this meaningful goal has been identified (collaboratively ideally), the physiotherapist (or multidisciplinary team) would identify a plan to work towards this; this plan would consist of the specific targets. This was the approach taken during rehabilitation for these participants, but then when they attended maintenance they were able to set their own goals, and many reported trying to increase the incline of the treadmill, walking faster, or walking for longer. It could be that further support would be needed to transfer this goal setting strategy, to a home environment. In addition, the fact the phone incremented the walk by one minute following seven 'just right' ratings might have encouraged some participants to see the phone as delivering a plan they *should* follow, like that given to them during rehabilitation, thus reducing the emphasis on the self-management. Finally, in completing the timed walks, participants might have decreased their activity in other areas, resulting in no significant change in activity overall. This would need to be explored in future research.

One approach that could be taken in this situation is to offer greater support to the individual, to encourage them to set their own goals. Scobbie et al., reviewed goal setting techniques and designed a plan to help rehabilitation professionals set goals in a more evidence based way (Scobbie, Dixon, & Wyke, 2011). This approach could be taken with self-management, encouraging the individuals to set action (how they will achieve their goal) and coping plans (how they will deal with setbacks) and ensure that, when the person reviews their goal, they review it in light of either past behaviour or an ambitious goal, to encourage discrepancy production. The plans could take the form of implementation intentions (see Section 1.1.4), However, this would only be appropriate if an increase in activity was the desired endpoint, rather than maintenance at the current level.

In comparison to healthy samples, there are no guidelines for the recommended level of activity for people with COPD. This means it is hard to provide an answer to the question how much activity is enough? During the pulmonary rehabilitation education sessions these participants had been introduced to the age appropriate governmental target of 150 minutes moderate intensity activity per week (30 minutes five times per week) in 'bouts' of at least 10 minutes (Bull & Expert Working Groups, 2010). However the recommendations advise appropriate tailoring to the needs and abilities of older adults, especially in the case of people with health needs. As would be expected from a group of people with COPD, there was a wide variation in pre-baseline levels of moderate intensity activity, however the majority of the participants were meeting the age appropriate guidelines throughout, and for those that weren't, it is not clear whether this was the limit of their capability, or something they could work towards. As with the Ex-SRES, measurement issues must also be considered with such a small sample. It is not clear what proportion of the changes in the CHAMPS results were due to the intervention. Over a 60 day period many aspects can affect someone's activities; differences in gardening and home maintenance, for example, were seen in this group over time.

The objective measurement of step count provides a more reliable estimate of individual activity than the self-report questionnaire, however what is 'enough' in terms of step count is also hard to ascertain. In a recent paper it was proposed that a daily step count of >4580 steps needs to be maintained by PwCOPD to avoid being classified as severely physically inactive[10] (Depew, Novotny, & Benzo, 2012). During the baseline phase only two of the seven participants achieved this level of activity as a mean, and this increased to three participants following the experimental phase. It could therefore be suggested that, although participants were in the maintenance stage of rehabilitation, further increases for the majority of the participants would be advantageous. The difference between the objective and self-report measures of activity raises questions. The CHAMPS indicated that this sample were meeting the recommended activity levels of age matched healthy peers, however the step count indicates the majority of participants would be classed as 'severely physically inactive'. This could indicate that participants are less active than they think, or that many of the activities reported on the CHAMPS were not being picked up accurately by the pedometer. The types of activities participants reported in the CHAMPS, the fact the pedometer has been validated with people with COPD, and previous research in this area (Pitta et al., 2006) would suggest the former.

5.2.3 Methodological factors

The decision was taken to focus on a small number of individuals and look at change within individuals over time, rather than looking at a larger number of individuals and examining change between groups. The rationale for using this method is presented in Chapter 4. This method has advantages in that the mobile device was assessed in a real-world setting, which confers a certain level of external validity on the study. While being cheaper and quicker to conduct than a pragmatic RCT. However, it does mean the results might be unduly influenced by individual events. As the intervention took place over a 60 day period, there are many potential sources of bias from injury, illness and new opportunities for activity that were not part of the intervention. As in between-group studies, the chance of these events occurring is equal in both groups (as they are not associated with the intervention, and provided there is no selection bias when assigning the groups). With a large enough sample, these anomalous events should cancel each other out. In time-series they would be equally likely to occur in the baseline phase as the experimental phase. However, while people in groups are independent, step count in an individual is not, so an injury or illness may affect several days within a phase, thus potentially affecting the outcome. While this would have a greater negative effect if a

[10] The World Health Organisation classification of 'severe physical inactivity' has been linked to 48 month mortality in those with COPD (Waschki et al., 2011).

mean of the phase was taken, within the simple *N*-of-1 design used here, consisting of a baseline phase (A), followed by an experimental phase (B); termed A-B designs; the researcher is looking for systematic change associated with the phase. There are approaches to protect against this in *N*-of-1 studies (Barlow et al., 2009), but none were deemed appropriate for the current research. For drug trials, A-B designs are often followed by a further baseline phase (A-B-A designs), so that if the change in outcome is isolated within the intervention phase, it is more likely to be caused by the intervention, rather than simply a result of change over time (Barlow et al., 2009). Although this type of design gives greater support to causality hypotheses, it is problematic in behavioural interventions (Barlow et al., 2009). Withdrawing a drug (after an appropriate washout period) might result in a return to baseline levels, however any intervention that involves learning, training or changing behaviour is anticipated to have effects beyond the intervention phase, so a failure to return to baseline levels would not indicate that the change was not due to the intervention, but instead may indicate that the intervention had worked as intended. In the current research it was hypothesised that the participants' awareness of their own activity would be increased by self-monitoring using the mobile device. This awareness would not be expected to disappear if the mobile device was taken away, therefore an appropriate baseline could not be collected following the experimental manipulation. For the same reason the order of delivery of baseline and experimental phases could not be randomised. Better reporting of potential influential events might have been introduced, but this would have to occur throughout the baseline and experimental phases, and there is a risk that this might increase participants' awareness of being monitored through the baseline phase, which would also bias the results.

Nock et al., suggest that an alternative approach is to assess whether the intervention is having an effect, and if not, changes could be introduced, termed an A-B-C design (2007). Recent psychological studies have utilised remote contact with the participant to randomise different phases of the intervention daily, to identify which components of the BCIs are having an effect (Quinn et al., 2013; Sniehotta et al., 2012). However, in the current research the existing technology did not have this functionality. Further suggestions include introducing baselines of varying length (and looking for change associated with the phase change whenever that is), however as the study was already 60 days long, longer would be an additional burden on the participant as well as introducing potential seasonal changes, and a shorter than 30 day baseline would have reduced the power of the study to detect differences using an ARIMA model.

Time-series analysis looks for change associated with phase. In these individuals there was high day to day variability, as evidenced by the lack of significant auto-correlation in six of the seven cases. Some authors recommend extending the baseline until stability is achieved, and only then introducing the experimental phase. In light of these results this approach would have been impractical, as already the length of time the study ran for potentially negatively affected recruitment, and, with potential seasonal effects, an appropriate level of stability may never have been achieved. Studying the individual is a promising approach to producing early quantitative data indicating whether a piece of technology has the intended effects with a target population. There are many experimental designs in this area, and as sensors and ambient data collection become more advanced, new opportunities for collecting individual level data will be introduced. Future work should continue to explore the potential of *N*-of-1 studies and associated designs in this area.

5.3 Conclusions

This chapter has reported the findings of seven mixed-methods *N*-of-1 studies to investigate the effect of an existing piece of persuasive technology in a novel population. The technology channel was a re-purposed mobile phone with software delivering BCTs derived from control theory. Initial evidence related to PwCOPD's engagement with the device, whether the persuasive technology would encourage changes in physical activity, and why this might be the case, was reported. Each *N*-of-1 combined qualitative interview data, with objective measures of mobile device use and step count.

People with COPD used the phone and achieved the goals set, but did not engage with all aspects of the intervention. There was reticence in the majority of cases for participants to increase their own goals; and the goals that were set initially were not sufficient to significantly change step count in six out of 7 people. However, the interviews suggested the potential for technology of this type to support changes in behaviour, if changes were made to the intervention content. This research highlights the importance of objective measurement of the behavioural outcomes of using persuasive technologies with a small number of people, so that improvements can be made prior to further testing. Participants were not always accurate in their perceptions of their own behaviour change, so relying on self-report could be misleading. Ensuring the credibility, positive interaction, as well as creating stronger links between intentions and behaviours and providing greater support to increase goals should all be prioritised to make this intervention effective for a greater number of people.

6 Study 4: Opinions of the target population and other stakeholders towards novel persuasive technology techniques – Background and Methods

6.1 Introduction

Study 3 described the evaluation of persuasive technology delivered using a mobile phone. Compared to the mobile phone apps available to the general public, the technology assessed was relatively simple. This has advantages in terms of ease of use, but could also be limiting in terms of continued engagement. In addition the findings from Study 3 indicate that greater support may be needed to encourage effective use of the technology to increase physical activity. To explore whether some of the more novel aspects of persuasive technology would be an acceptable addition to the technology evaluated in Study 3, the opinions and preferences of key stakeholders were sought. The background and methodology for the current study will be described in this chapter, with the results and discussion presented in Chapter 7.

This chapter describes the persuasive technology techniques (PTTs), behaviour change techniques (BCTs) and features used by apps ranked as top by app stores, and designed to increase physical activity. It then goes on to describe how these have been used to develop three novel scenarios, and five potential feedback screens, that depict possible persuasive technology systems to increase physical activity in PwCOPD. Following this, the methodology for Study 4 is described.

6.1.1 Background

As described in Chapter 1, any technology that is designed specifically to change opinions and/or behaviour can be described as 'persuasive technology' (Fogg, 2003). The most commonly available persuasive technologies are mobile applications or 'apps'; these can target both attitude and behaviour changes, and are available to download onto smart phones and tablet computers. The popularity of these apps to change health and fitness behaviours in the general public can be seen by the tens of thousands of apps categorised under 'health and fitness' in online stores for iPhone®, Android®, Blackberry®, Windows Phone® and Nokia® devices. However, many of these existing apps are not based on recognised theories of behaviour change, and do not have reliable efficacy data to support their claims (Rabin & Bock, 2011; Rosser & Eccleston, 2011)

To recap and elaborate on the information provided in Chapter 1; previous research has identified a list of PTTs that could be used by developers to encourage changes in attitudes and/or behaviour (Oinas-Kukkonen & Harjumaa, 2009). The techniques form part of the Persuasive Systems Design (PSD) Model (Oinas-Kukkonen & Harjumaa, 2009). The PSD model encourages consideration of the context of use, and the user, as well as defining what qualities the system could have in order to persuade in addition to the PTTs. These PTTs, in some respects, represent a 'toolkit' for designing persuasive systems and are presented in four categories (Oinas-Kukkonen & Harjumaa, 2009):

a) Primary task support: Techniques that enable easier performance of the target task;

b) Dialogue support: Techniques that encourage interaction with the system;

c) Credibility support: Techniques that encourage the user to trust the system;

d) Social support: Techniques that enable the user to access social support from other people.

The PSD model has previously been used to identify effective techniques used in online alcohol and smoking interventions for the general public (Lehto & Oinas-Kukkonen, 2011). However, so far, it has not been used in the context of managing long-term health conditions.

6.1.2 Seeking user opinion from key stakeholders

For a BCI to have the desired effect on behaviour, the intended recipient needs to engage with it (and remain engaged with it) in order to gain the maximum benefit (Davies et al., 2012). Insufficient user involvement at the design stage may contribute to reductions in both effectiveness and usability (Pagliari, 2007), which could lead to poor engagement. It is therefore important to seek the opinion of key stakeholders.

People with COPD and their carers are likely to be older adults, which can result in a wider range of characteristics, experiences, disabilities and capabilities than younger age groups (Newell, Gregor, Morgan, Pullin, & Macaulay, 2011). In some cases this might make older adults' reactions to technology very different to a younger age group, however, it is important not to generalise, as in some cases the reactions of older and younger people towards technology will be the same (Newell, 2011). It has been noted that 'eliciting requirements from older people, who often have limited experience of ICT [Information Communication technology], for products which do not yet exist, poses unique problems' (Eisma et al., 2004, p.131). In addition to an older population, and a technology at an early stage of development, the concepts involved in persuasive technology are innovative. Rather than static pages of information, persuasive technologies use the ability that people have to interact both with technology, and through technology, sometimes referred to as Web 2.0 functionality. For the researcher, this can make persuasive technology complex to explain, especially when the proposed users are people who are perhaps less familiar with technology in general (Waycott et al., 2012). These concerns can make it difficult to recruit a population of older adults that could be considered representative (Eisma et al., 2004; Zajicek, 2004).

Once a sample is recruited there may be further challenges to accurately gathering opinions and preferences. Older adults are less confident than younger adults when expressing opinions about technology (Dickinson et al., 2003; Newell, Carmichael, Morgan, & Dickinson, 2006) and it is the responsibility of the researcher to ensure that the value of the participant's contribution is emphasised and jargon is removed from descriptions to allow full participation (Eisma et al., 2004). Older adults are also more likely to attribute any problems associated with technology to their own failings, rather than failings of the technology, and express more positive opinions; especially in the presence of the developers or those personally involved in the research (Eisma et al., 2004; Newell et al., 2006). The tendency for interviewees to give what they perceive to be the *correct* answer to an interviewer is known as the social desirability bias and, while this is not unique to this situation, Eisma et al., and Newell et al., report that technology research with older adults may be particularly vulnerable to this source of bias. When recruiting older adults therefore, researchers and designers should be aware of the potential differences between themselves and the older adults, and try to reduce socially desirable responses where possible.

In 2002, the UTOPIA project (Usable Technology for Older People: Inclusive and Appropriate) was established to try and explore and address some of these problems, and to develop new or adapted methodologies to ensure suitability for older people (Dickinson, Eisma, Syme, & Gregor, 2002; Eisma et al., 2004). The UTOPIA project looked at the relationship between older adults as the potential users of a technology, and the designers of technology. For this relationship to be effective in terms of developing a useful and acceptable new piece of technology, two separate *understandings* must be reached. First, older adults must understand the technology that is being proposed and be able to give opinions and make valued contributions. Second, designers must understand the older adults, in a deep and empathic way, as potential users of the technology. Several innovative suggestions have been proposed to ensure clear communication between older adults and designers. For example, researchers have explored using theatre to bring concepts to life in a way that encourages designers to ask frank questions and openly discuss without fear of offending the older adults; as they are being played by actors (Newell et al., 2006; Newell et al., 2011), or simulating some of the effects of ageing, so that designers can experience these first hand (Holzinger, Searle, & Nischelwitzer, 2007). To enable a full understanding of the technology by the older adults, researchers have written ‘pastiche’ scenarios where well-known characters such as Bridget Jones or Ebenezer Scrooge use new technology (Blythe & Wright, 2006). However, these techniques are time consuming and resource intensive to do well. It has also been suggested that by fictionalising the user (through theatre or text) the designers are actually being taken a step away from the actual users (Blythe & Wright, 2006).

In addition to the above more innovative approaches, adaptations to more traditional methods of user-centred design such as focus groups, workshops, interviews and surveys have also been suggested (Eisma et al., 2004). These approaches can be less resource intensive than employing actors, or developing detailed pastiche scenarios, however each has both advantages and disadvantages. Focus groups provide a social space and the potential for ideas to develop through interaction between participants. However, it has been found that older adults can be inclined to deviate substantially from the intended topics of discussion (Lines & Hone, 2004). To address this Lines and Hone increased the level of structure within the group and, while this was reported as satisfactory, the authors concluded that semi-structured, or structured interviews might have been more efficient (2004). Workshops allow potential users to work ‘hands on’ with the proposed technology. However to be effective, a working prototype of the system is needed. Interviews can be useful, especially if conducted in the participant’s home as the participant would be more likely to feel at ease, and there would be an increased chance of useful spontaneous information being gained (Eisma et al., 2004). However, being face to face with the researcher could increase the likelihood of socially desirable responses. Focus groups, workshops, and interviews rely on recruiting a small number of representative people, then using this sample to generalise to the general population of interest. As explained above, this is problematic when the target users are as diverse as older adults are (Zajicek, 2004).

Surveys have the potential to gather information and opinions from a wider group of people, and the increased anonymity could reduce social desirability bias. However, as older adults are more cautious in their responses, there could be problems with over use of the central point on a Likert scale (the I ‘don’t know’ category; Dickinson et al., 2003). Each of the methods for gathering user opinion has potential flaws when used with this population. It was decided therefore, that rather than choosing a single method, mixed methods would be used. Interviews and surveys were chosen as the methods of data collection that would provide both detailed in-depth data from a small sample, and less detailed but potentially more generalizable data from a larger sample.

6.1.3 Using Mixed Methods

The rationale to use mixed methods was twofold, a) to produce a more complete picture of the research area; referred to as the *completeness* rationale and b) to address the possible bias in each individual method with the other; referred to as the *offset* rationale (Bryman, 2008). In the current study, the same materials were presented to participants in both the interviews and the surveys (see Section 6.2). This approach was taken to enable successful integration, through the consistency of the concepts across the qualitative and quantitative data (Fetters, Curry, & Creswell, 2013).

Data was collected using the two methodologies simultaneously and then the data were analysed separately; interview analysis, followed by survey analysis. This type of design, where qualitative and quantitative data are collected in parallel, then combined, can be referred to as a *convergent mixed methods design* (Creswell & Plano Clark, 2011) or *parallel convergent design* (Fetters et al., 2013). According to Fetters et al. (2013), integration can result in three different types of findings; i) confirmation, where the findings from the two strands of data agree; ii) expansion, where similar themes are found, but one strand may provide additional information about the findings and; iii) discordance, where the findings from the two strands do not agree. The importance of identifying and explaining any discordant data has also been highlighted by other authors (e.g. O'Cathain et al., 2010).

6.1.4 Aim

The aim of Study 4 is to ascertain the opinions of, and preferences regarding, persuasive technology techniques to encourage and support increases in physical activity from PwCOPD and other key stakeholders.

6.2 Methodology

6.2.1 Material development

Scenarios

As discussed in Section 6.1.3, stakeholders must understand the technology that is being proposed in order to give meaningful opinions. To enable this understanding, three scenarios were designed for use in this study. The scenarios were similar to storyboards and were in the form of Powerpoint slides that represented either computer screens or phone screens (see Appendix III for the survey which contains all scenarios and feedback screens). In the interviews, the interviewer clicked through the slides, describing the scenario as they did so. Following each scenario, the interviewer asked specific questions and encouraged discussion with the participant (see Appendix III for the semi-structured interview guide). The surveys presented the same slides but the description was provided by text on the screen that accompanied each slide.

Each scenario describes an older adult who either has COPD, or is described as experiencing breathlessness, who is told by their doctor that they need to increase their physical activity to 30 minutes per day. In each scenario, the older adult has chosen to do this with the help of a mobile phone and a website. All of the scenarios included the five BCTs related to control theory (Abraham & Michie, 2008; Carver & Scheier, 1982):

1. Prompt intention formation
2. Prompt specific goal setting
3. Prompt self-monitoring of behaviour
4. Receive feedback
5. Prompt review of goals

These are the same BCTs used in the technology assessed in Study 3. These BCTs were chosen to enable the findings of Study 4 to inform the further development of this technology. It was decided to keep the same theoretical approach across the three scenarios to identify the effect of the persuasive technology techniques and features on the opinions of key stakeholders. Therefore, in addition to the above BCTs, different PTTs identified within the PSD were also used (Oinas-Kukkonen, Harjumaa, 2009).

As described in Chapter 4, the advice given to develop effective persuasive technologies highlights the importance of identifying any similar technology that has been found to be effective, and imitating it (Fogg, 2009c). There are currently many thousands of apps available to encourage a person to increase their physical activity, and these could all be considered similar in terms of the behaviour targeted. However, there are no data available on how successful the majority of these apps are in terms of promoting physical activity. Apps designed specifically for research purposes are more likely to be evaluated in terms of effectiveness. However, these are often not the apps that are available to download by the general public. The only metric for success available for the vast majority of commercially available apps are the number of downloads they have received and reviews from other users. Android, iPhone and Windows phone marketplaces all identify the top apps in health and fitness. Although there is some secrecy related to the ranking of apps in app stores (Conroy, Yang, & Maher, 2014), it is thought to rely on the number of downloads, not counting users who download the app then subsequently uninstall it (Carara, 2012). Apps categorised as health and fitness relate to a wide range of topics in addition to physical activity (the target behaviour of interest here). Removing unrelated apps from the list (those relating to reproductive health or diet for example), the top 5 physical fitness apps were identified in the iPhone store and Windows Marketplace and the top 5 free and top 5 paid apps were identified from Google Play. The app descriptions given on the websites were coded for persuasive technology techniques, and an overview of each app was written to describe the features that were used to deliver the PTTs.

The scenarios were then designed to incorporate PTTs and features identified from these apps. The three scenarios feature; dialogue support, primary task support and social support PTTs. Credibility support was not explored in a separate scenario as the research was being undertaken by the University of Sheffield, and this might influence participants' perceptions of credibility separate from the scenario contents. All the scenarios included the PTTs *self-monitoring, tailoring* and *reduction* (see Table 1.1 for definitions). As the apps displayed feedback in a wide variety of ways, in addition to the three scenarios, following the pilot (see section 6.2.3) five separate feedback screens were designed from previous work conducted by the SMART research team and the approaches taken by the commercially available apps. An overview of the scenarios and feedback screens is given below, for complete walkthroughs see the survey reproduced in Appendix III.

Scenario 1 – Virtual coach system (VC) - This scenario used dialogue support PTTs to encourage interaction between the user and the system. The PTTs used were *personalisation*, *social role*, *suggestion*, *reminders*, *praise* and *simulation.* In the scenario, the virtual coach used the name of the user 'Joyce' to personalise the system and encourage interaction by taking a social role. The coach leads the user through progressive goals. Although there is the option to change the goals, suggestions are made by the coach. The user can then choose to receive reminders to complete the activity (see Figure 6.1). While the user is performing their walk, there is the option to receive audio encouragement from the coach (in the form of recorded messages telling the user how many minutes they have been walking, or when they are half way to their goal). The feedback is presented as a graph, with praise and encouragement from the virtual coach. There is also an outline of an exercise plan with daily walking goals increasing to reach an overall goal (walking for 30 minutes) - a simulation of what may happen if the user follows the coach's suggestions. Tips and advice are offered in relation to common barriers to performing physical exercise.

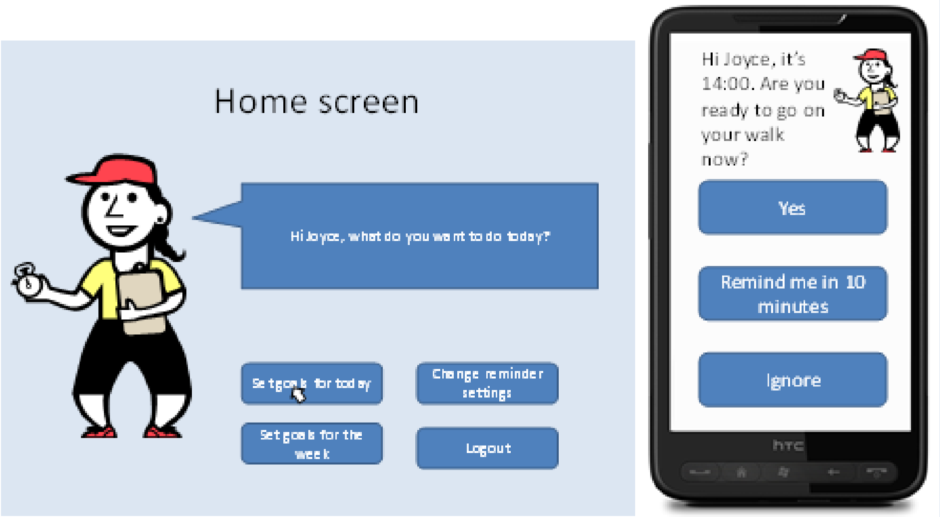

Figure 6.1: Screenshots from the virtual coach (VC) scenario showing the homepage and a reminder

Scenario 2 – Music and maps system (MM) - This scenario used only the primary task support PTTs that all the scenarios used. The content of this scenario was based on the format of many of the existing physical activity apps. In this scenario, the user can set goals and track activity using their mobile phone. While walking, the user can choose music to listen to. Following the walk, feedback is offered on a satellite map, as a summary table, or on a calendar (with activity shown on each day). Local exercise facilities can be highlighted on the map (see Figure 6.2).

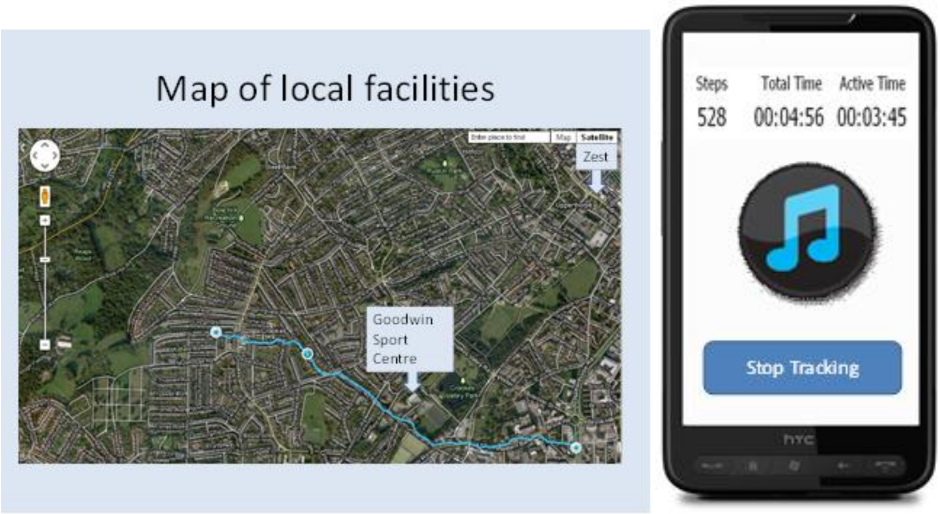

Figure 6.2: Screenshots from the music and maps (MM) scenario showing the map feedback and playing music

Scenario 3 – Online community system (OC) - This scenario used the dialogue support PTT *rewards* and the social support PTTs *recognition, social comparison, co-operation* and *competition* and was based on building a community of like-minded users to support increases in physical activity (see Figure 6.3). The role of the system was to provide computer mediated communication between peers, while encouraging interaction through the PTTs outlined above. In this scenario activity is tracked using a mobile phone, then information can be shared with other users. Competitions and collaborations with other users can also be entered into. Points are given based on goal achievement (the details of the goal completed are not shared) and there is the potential for both virtual (stars/ trophies on profile) and 'real-world' rewards (either through vouchers or donating money to charity).

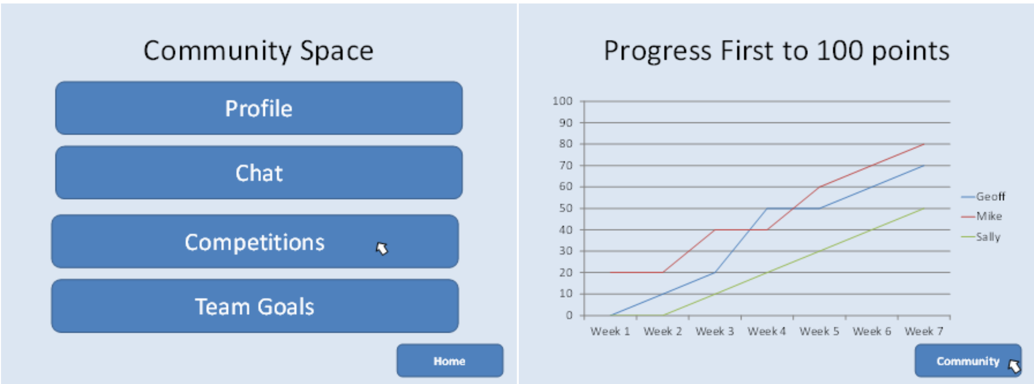

Figure 6.3: Screenshots from the online community (OC) scenario showing the community space and competition graph

Feedback screens- The feedback screens all displayed the same data, but in different formats. The first was a line graph showing both the minutes walked and the goals set each day (FB1); the second depicted the same information in the form of a bar graph showing the goal and "minutes walked" each day (FB2); the third showed a single bar for each day coloured green if the goal had been reached and yellow if it had not (FB3); the fourth showed a tick if the goal had been reached, a neutral face if the goal had been started but not reached and a red angry face if no activity was done at all (FB4); and finally the fifth showed flowers in a garden, the different heights of the flowers represented time spent walking and the type of flower indicated whether the daily goal had been reached (screenshots for these are presented with the results).

Interview and survey

To prepare for integration of the data, both the survey and the interview schedule followed the same basic format. Background questions were asked related to COPD, current level of physical activity, current use of technology and whether participants had any previous experience with persuasive technology. The background section was followed by showing the VC scenario and questions relating to participant's opinion, then the five feedback screens were shown with questions relating to opinion and preference after each, followed by the MM scenario with questions relating to opinion, and the OC scenario with questions relating to opinion. Finally an overall opinion, and preferences for specific scenarios and components were sought.

The survey was delivered both on paper and online. The questions used to assess participants' opinion of each scenario were taken from a translation of the *perceived persuasiveness* measure (Drozd, Lehto, & Oinas-Kukkonen, 2012). Additional items were added that assessed perceived enjoyment and perceived effectiveness. All the items were answered on a 7-point Likert scale. The eight items used were summed to make a single scale score for perceived persuasiveness for each scenario. Cronbach's Alpha[11] was calculated for each scenario and were as follows: Virtual coach (VC) α= 0.93; Music and Maps (MM) α= 0.93; Online Community (OC) α= 0.95. Four items were used to assess participants' opinion of the feedback screens (attractive, confusing, useful and easy to understand), with the same Likert scale as the scenario questions. These were summed to make a feedback score for each of the five screens. The Cronbach's Alpha scores were as follows: Line graph (FB1) α= 0.76; blue and red bar graph (FB2) α= 0.78; green and yellow bar graph (FB3) α= 0.83; faces (FB4) α= 0.73; flowers (FB5) α= 0.73. The only differences between the paper and the online survey were the number of pages

[11] A measure of internal consistency used to ascertain reliability of a scale (Lund & Lund, 2013)

and the presence of automatic branching. All the study materials for both the interview and the survey study are presented in Appendix III, these include the interview guide and the survey as well as participant information sheets and consent forms.

6.2.2 Ethical considerations

The interview reported here was conducted as the second part of an interview for the SMART 3 (the associated research project that aims to develop a holistic self-management technology for PwCOPD). Ethical approval for the interviews was obtained from the ethics committee at the School of Health and Related Research (ScHARR) at the University of Sheffield, and ethical approval for the survey was obtained from the University of Sheffield, Department of Psychology Research Ethics Sub-Committee. PwCOPD were recruited through The British Lung Foundation (BLF), and online. Ethical approval for this was granted by the BLF. NHS ethical approval was gained to interview health care professionals (HCPs) employed at a specialised centre providing care to people with lung conditions in South Yorkshire (Breathing Space; see Appendix III: iii for ethical approval letters). All participants that were interviewed were sent an information sheet prior to the interview (copies were also available at the interview). Participants provided written informed consent, including consent for the interview to be audio recorded (see Appendix III: iv for a copy of the consent form). Participants who completed a paper survey were sent an information sheet and two copies of the consent form with the survey and instructions to return one completed consent form with the completed survey. For the online support groups, the group or mailing list moderator was contacted in the first instance with information about the topic of the research, the length of the survey and the link. Permission was sought to post the link on the forum, and if permission was granted either the thesis author, or the moderator, posted the link. The same consent statements as for the paper survey were provided with a single statement 'I agree with the above five statements' which could be answered 'yes' or 'no', and was a required answer before continuing with the survey.

6.2.3 Piloting

The interview was piloted with a person with COPD who was a member of the Patient and Public Involvement panel (PPI). The interview was not considered as a PPI activity, and the individual took the role of a participant throughout. There were no problems of comprehension with the interview material and the timing was appropriate so no changes were made to the interview in response to the piloting. However, due to ongoing discussion within the research team it was decided to add example feedback screens to gather opinion and preferences on alternative formats. As no other changes were made in response to the pilot it was decided to include these data within the main analysis.

The online survey was tested to ensure that all branch questions were working effectively, and that the Powerpoint slides were displayed appropriately. The paper survey was piloted with four people aged 31 – 60 to test whether the branch questions were clear, and to establish how long it took to complete the survey. Time taken ranged from 15 – 30 minutes. No problems were reported with the branch questions. Changes made following the pilot were to reverse some items and correction of an error in the information section (changes made to both online and paper versions of the survey). As those who piloted did not have COPD, the data were not used in the analysis.

6.2.4 Participant recruitment

Interview

PwCOPD and their carers were recruited from Breathe Easy group meetings in South Yorkshire. Information sheets were provided to those present and spare copies with stamped envelopes were provided to the group co-ordinator to send to any members who were not present at the meeting. Potential participants then contacted the researcher and an interview was arranged. Carers were invited to join the interview if they, and the person with COPD agreedCarer information sheets were also provided to participants with COPD to pass on if they agreed. HCPs were contacted through a gatekeeper in Breathing Space. Interested HCPs contacted the researcher to arrange an interview. For PwCOPD and their carers, interviews took place at their home; HCPs were interviewed at Breathing Space.

Survey

Participants were recruited online through online support groups related to COPD and by (postal) mail through the BLF Breathe Easy network of support groups. An information letter was sent to the BLF London office to be distributed to the regional coordinators in their monthly mail out. The coordinators then distributed the information to the individual groups in their region. Those contacted through the post were given a number to call to receive a paper copy of the survey, as well as the link for online completion. This approach has been described as mixed-mode internet-mail survey in terms of both recruitment and completion (de Leeuw & Hox, 2008).

34 online support group moderators were contacted (including the BLF forum). Groups were found by searching the internet and identifying COPD related groups on Yahoo Groups. Six moderators agreed to post the link and two further groups were posted to by one of the moderators. One online support group rang the researcher and requested 30 paper copies of the survey as they had an associated face to face group as well. The recruitment by paper

occurred after the online recruitment, as the mail outs to the BLF Breath Easy groups were only sent monthly. 70 responses had been received to the online survey prior to sending the adverts out to the Breathe Easy groups. As the response had been so positive (70 responses from 34 groups initially contacted) there was a concern that, if all 250 Breathe Easy groups were contacted, the expense and time required to send out all the paper surveys would be too great. To assess the response rate, three regions were selected by numbering all the regions (apart from the North region as some of these groups had been contacted to take part in the interviews) and using a random number generator to identify numbers; London & South West (90 groups), Scotland (19 groups), and North West (31 groups), making 140 groups in total. Adverts were sent out to these groups in their monthly mail out from the BLF office and contained information about the research a contact telephone number to request a paper copy (with postage paid return envelope) and the link for online completion.

6.2.5 Data analysis

Interview

All interviews were audio recorded, transcribed verbatim and checked against the original audio file for accuracy by the thesis author. In one case, due to a malfunction, the recorder stopped around 15 minutes before the end of the interview. This was noticed at the end of the interview and notes were made at this point to cover the time missed. In some cases the background questions in the interview reported in this chapter had already been covered at the beginning of the full interview. To ensure that no pertinent information was missed, the beginning of the full interview was also listened to and descriptive information was extracted. Framework analysis was used to analyse the verbatim transcripts using QSR International's NVivo 9.2 software. (QSR International Pty Ltd, 2010).

Framework analysis consists of five stages: (i) Familiarisation; (ii) identifying a theoretical framework; (iii) indexing; (iv) charting; and (v) mapping (Ritchie & Spencer, 1994). Familiarisation with the data was achieved through conducting the interviews, transcribing and checking the transcriptions against the audio files. Initial *a priori* themes were identified and coded. Transcripts were indexed using these themes; additional themes and sub-themes identified during this process were then added to the framework. At the point of adding a new sub-theme, previously indexed transcripts were checked to identify any further information that might pertain to the newly identified sub-theme. Once the process of indexing was complete, all themes were checked, to ensure that only relevant information was coded in them, and all transcripts were checked to ensure that the data had been coded appropriately. The data was then displayed in framework matrices. A framework matrix was made for each of the themes; individual interviews formed each row and the sub-themes formed columns. Each cell then links to any sections of the transcript, from a single interview, which are related to a single sub-theme. Charting involves summarising the verbatim data associated with each cell so that the overall matrix becomes populated with useful concise summaries of what has been said.

Once the process of charting was completed, the framework matrices were printed on a number of A3 sheets of paper, to provide an overview of the data. Descriptive accounts of the contents of each theme were then produced, paying particular attention to any contradictory findings, and any evidence of differences between sub-groups (people with COPD, carers, and HCPs). Mapping and interpretation of the data with consideration of between group differences was then conducted to identify potential explanatory accounts. The results were considered in light of existing research in the area.

Opinions were gathered by asking questions about the scenarios, and specific features within them. Preferences were identified by asking participants to identify their favourite feedback screen (*n*=22, as this was not asked in the pilot study) and which scenario they would use (or recommend to others in the case of HCPs). As part of the integration, to allow comparison with the survey data these responses were converted to a quantitative data count (O'Cathain et al., 2010). If a clear choice was made, the scenario or feedback screen was given 1. If a participant replied that they would choose a combination of two scenarios or feedback screens, or that two were equally favoured, each was given 0.5.

Survey

The postal surveys were entered into SPSS 17.0 (SPSS Inc., 2008), and their accuracy was checked against the original. The online responses were downloaded from the Survey Monkey website. The IP addresses were checked for duplicates that might indicate that the same person had completed the survey twice; however, no duplicates were found[12]. Online and paper responses were pooled into a single SPSS file (with mode of completion included as a variable). Two codes were used for empty cells, one for data that was missing and the other for empty cells caused by branching (i.e., for questions where the participant was not

[12] It should be noted that previously the IP address was a good check for duplicate respondents, as it was a static number associated with the computer. In recent years the static IP has been replaced with a dynamic IP address, which means that in many cases the router provides a new IP address every time a computer connects. It is not certain therefore, whether people may have completed the survey more than once. As there is no monetary gain from duplicate completion this is not considered a serious threat to the validity of these findings. However, in the future, alternative quality checks would be considered.

supposed to provide an answer). The data were recoded so that a higher number always represented a more positive opinion.

It was hoped to use a mixed ANOVA to investigate the effect of scenario (repeated measures factor, 3 levels) on perceived persuasiveness, the effect of feedback screen (repeated measures factor, 5 levels) on feedback score, and to look at the influence of the covariates of level of breathlessness, current level of physical activity and current level of mobile phone use (identified from the interview data as potentially influential). However, as the assumptions for an ANOVA (normally distributed data, and heterogeneity of covariance) were not met by the data, the Friedman test (with the Wilcoxon signed rank test) was used as non-parametric alternative. Preferences were calculated using the ranked score given to the individual techniques and how this relates to the categories of persuasive technology techniques, primary task support, dialogue support and social support.

Thematic analysis was conducted for the open ended responses, including familiarisation with the data, generating initial codes, grouping codes into themes, defining the themes and reviewing these to ensure they captured the data appropriately (Braun & Clarke, 2006). As the detail available from the open answer survey questions was minimal, the additional step of creating a thematic map of the data described by Braun and Clarke was not undertaken here (2006).

6.2.6 Integration Strategy

An integration matrix was designed to allow side by side comparison of the two strands of data (Creswell & Plano Clark, 2011; O'Cathain et al., 2010). Many different matrix designs are possible, but the key aim of this approach is to ensure that the data are displayed in a way that is clear, and allows the research questions to be answered (Miles & Huberman, 1994). Key topics of interest form the rows of the matrix, with evidence from the interviews presented in one column and evidence from the surveys in a second column. A third column outlines whether, taken together, the integrated evidence is confirmatory, expansive or discordant (Fetters et al., 2013).

7 Study 4: Opinions of the target population and other stakeholders towards novel persuasive technology techniques – Results and Discussion

7.1 Interview Results

7.1.1 Background questions

Twenty-three interviews were conducted with 28 participants. Sixteen people self-identified as having COPD, five of whom were interviewed with their carers, and seven HCPs were interviewed. For the people with COPD (PwCOPD) who participated in this research, ages of PwCOPD ranged from 52 to 89 with an average of 71 years (*SD* =8.26) and the majority lived with a partner (81%). Of the whole sample interviewed 57% (31% of the PwCOPD) were female (see Table 7.1)

Table 7.1: Participant Demographics

	N	*Female %*	*Mean age*
PwCOPD	16	31	71
Carers	5	80	NA
HCPs	7	100	NA
Overall	28	57	

PwCOPD: People with COPD; HCPs: Health Care Professionals

The severity of COPD was not assessed formally, but participants were asked to what extent they felt that COPD impacted their lives. Eleven of the PwCOPD (69%) reported having difficulty walking outside due to COPD, and either using a scooter, a wheelchair, or stopping frequently for rests if they were required to walk outside. Six participants were using oxygen, either at home or ambulatory (38%). Only one PwCOPD said that they did not feel that COPD had much of an impact on their life and ability to do day-to-day activities.

7.1.2 Opinions and preferences towards persuasive technology

The data were initially coded according to *a priori* themes and sub-themes drawn from the interview schedule; technology (subthemes: previous experience of technology and previous experience of persuasive technology), feedback (subthemes: the five individual feedback screens) and features (subthemes: VC, MM and OC scenarios). During coding, new themes and sub-themes were identified and coded, and the thematic structure is displayed in Table 7.2. Following this indexing process, the data were charted and summarised. In the results section below, to aid clarity and prevent repetition, a full presentation of all the *a priori* themes is not given. Instead the more explanatory sub-themes are described, for example the theme *goals* presents data related to all three scenarios (as they all contained goal-setting). This provides an opportunity to compare and contrast the opinions given related to goals. This information is not then presented again under the individual scenario themes.

Table 7.2: Themes and sub-themes identified through framework analysis. A priori themes indicated in bold

Theme	*Sub-theme*	*Sub-theme*
Technology	**Previous experience of technology** **Previous experience of persuasive technology** Concerns	
Feedback	**Individual feedback screens** Maps Rewards Summary Information that should be presented Important features of a feedback display Displaying negative feedback	
Goals	Choosing an initial goal Regulation of goals Team goals	
Individuality	Everybody's different People who would use this type of technology	
Features	**Virtual coach scenario** **Maps and music scenario** **Online community scenario**	Audio, Reminders Audio Competitions
Social support		
Motivation	Carer as motivator Factors external to the system that motivate or de-motivate Features of the system that motivate or de-motivate	

Technology

Previous experience of technology – The majority of participants mentioned that they had a mobile phone, but this ranged from simple phones that were rarely used (e.g., kept in case of emergency):

> *'I've got a mobile phone, you know, not that I use it like, but I, I have started depending on it more, taking it with me just in case' Ppt 3,PwCOPD*

to smart phones that were used to access the internet:

'I've got a map on my iPhone and I use it...to find out where I'm going to pick people up' Ppt 16, PwCOPD

Experience of other technology ranged from satellite navigation systems to SMART TVs, with some participants mentioning that younger relatives had shown them how to use pieces of technology:

'I've got all the tech, love, but I don't understand most of it, I get my kids round for that' Ppt 9, PwCOPD

Previous experience of persuasive technology – The majority of PwCOPD hadn't heard of persuasive technology:

'No, [not] that I can bring my mind to anyway, no' Ppt 8, PwCOPD

Some people gave examples of non-interactive technology that aims to change behaviour such as yoga videos, information on the internet or adverts on TV:

'Your television's always trying to change you isn't it?...We get it 24 hours a day in this country' Ppt 3, PwCOPD

The only persuasive technologies mentioned by PwCOPD and their carers were electronic cigarettes (which were seen negatively) and the Wii fit (which was seen positively). HCPs on the other hand had greater experience of persuasive technologies; three HCPs had used persuasive technologies, either mobile apps or the Wii, and one HCP recognised the description of Nike +®, although she didn't use it herself.

'My exercise planner it looks at diet and exercise, you put in what you do every day' Ppt 14, HCP

What made the technologies persuasive for those who used them was getting information about how their activity affects health (specifically weight). Only one person was currently using a persuasive technology app; another mentioned she needed to be *'in the zone'* to use an app like that; and the person who used the Wii said she didn't follow the advice given when the Wii told her to do more exercise.

'When I've been trying to watch what I'm doing and trying to exercise then when I'm not I just ignore it because I think I don't need something to tell me I'm eating too much and not exercising thanks very much , I already know that.' Ppt 13, HCP

Concerns – Concerns were expressed related to PwCOPD's ability to use technology, the content of the proposed technology, and the inconvenience of using technology. All three groups of participants were concerned that PwCOPD would not manage with the technology. Even those participants who were familiar with some forms of technology expressed concern at the use of smart phones. HCPs used examples of PwCOPD struggling to use their own mobiles or stopwatches, from classes that they had taught, to illustrate their concerns about whether PwCOPD were sufficiently able to use technology. One carer was concerned that if a user had difficulty getting the persuasive technology to work this could result in worry, or panic. Adequate training and support was mentioned by some to address these concerns:

> *'I think you've got to have a briefing session…To set it up and get them to understand where, where it's coming from. And then I suppose they're going to be helped over an initial period of using it aren't they, to see that they are doing it right' Ppt16, PwCOPD*

There was additional concern expressed by some participants that, if future systems were not kept simple or adequately supported, it could waste money as they would not be used

> *'Like I say then it comes down to being a waste of finance if it's stuck there dust collecting and they're sat there and not following from it' Ppt 5, Carer*

Thus, the findings suggest that any future system would need to be kept simple, and that training and support would be needed to keep people engaged and to avoid money being wasted by providing equipment to people who would not use it.

In addition to concerns about using technology generally, there was also a concern raised that, if the technology was taking an active role in suggesting physical activity goals, PwCOPD may be physically unable to achieve what the phone had suggested:

> *'I think it depends on the person, they might physically not be able to do what the computer's telling them' Ppt 20, HCP*

A few PwCOPD said that they would prefer to receive physical activity support face-to-face or said that they did not carry their mobiles with them.

Feedback

The *a priori* themes were *'Individual format feedback'* which referred to comments that were specifically linked to one of the feedback screens (FB1-FB5); and the '*Maps'; 'Rewards';* and *'Summary'* sub-themes, which contained comments linked to these approaches to providing feedback shown in the scenarios. Three emergent sub-themes were identified that illuminate more over-arching principles for feedback; '*Information that should be presented' 'Important features of a feedback display'* and '*Displaying negative feedback'.*

FB1 - PwCOPD on the whole said that it was simple and that they could understand it, although others may not be able to. One person mentioned the *'terrible dip'* (caused by no activity on Friday); although she said that this would motivate her. HCPs expressed greater concern about the dip being perceived as overly negative and thought that PwCOPD would struggle to understand the line graph format.

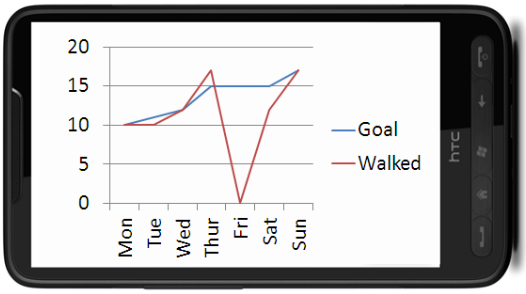

Figure 7.1: FB1

FB2 – This was the most popular format, although two PwCOPD said that they found the line graph clearer. HCPs had a strong preference for this format due to the comparison of goal and activity, and commented that it is not as negative looking as the line graph when no activity is completed. However, one HCP did say that it would not be suitable for everyone, as some PwCOPD have no experience of using graphs at all.

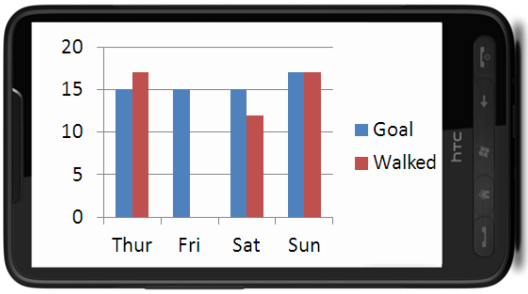

Figure 7.2: FB2

FB3 – This graph caused some misunderstanding among participants. For example some participants said that it was clearer having a different colour for each day (whereas the colours indicate whether a goal has been completed or not). However, other participants said that the fact that the bars were not next to each other (as in FB2) made it clearer, and having more days shown on the display was an advantage. Some people commented that they missed the comparison present in FB2, and HCPs were divided on what information was most important to present – some stated that whether the goal was reached or not was most important, while others felt that how close people were to the goal was more important than whether it was reached or not.

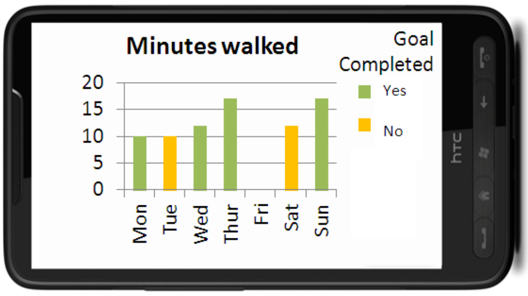

Figure 7.3: FB3

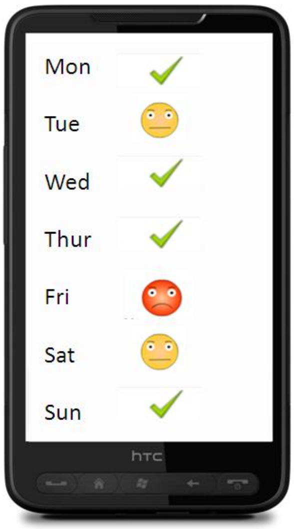

Figure 7.4: FB4

FB4 - Some participants suggested that FB4 might be good in conjunction with one of the other screens, but would not be suitable as a replacement. HCPs did not like it as an alternative to the previous screens (FB1-3) due to; the lack of comparison between goal and achievement; the lack of detail given; and the judgement inherent with it. One HCP thought that it would be good for people who didn't understand any graphs, whereas another thought that anyone who would be willing to participate in this project would at least be able to read a bar chart. PwCOPD were divided, one found it funny and liked it for that reason, whereas another thought that it was childish.

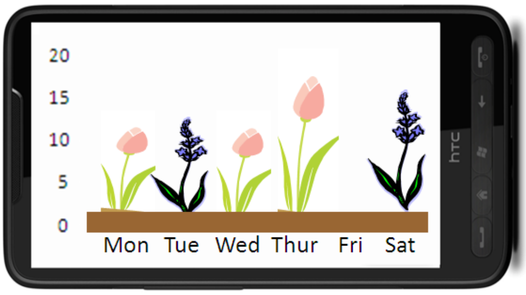

Figure 7.5: FB5

FB5 - Generally it was thought that FB5 was too confusing and not clear enough. It was mentioned that men would not like the flowers; one man with COPD suggested that using people in the display instead of the flowers, and that the people could then grow taller the more you walked. Some HCPs liked the display and thought that if the PwCOPD liked gardening they might particularly like it, however the overall opinion was that FB5 was not clear enough.

Preferences for feedback screens

FB2 was the most popular, especially amongst HCPs. This was due to the clear comparison between goals and activity and that the bars were seen as easier to understand than the other formats (see Figure 7.6). Although some participants said they liked FB5, it was thought to be too confusing overall.

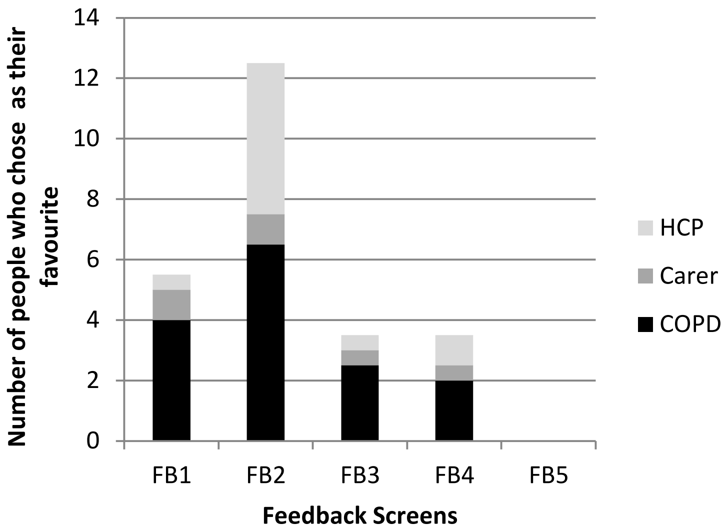

Figure 7.6: Preference for feedback screens

Mapping walks - Maps were not thought to be useful if someone's mobility was very low, they knew the area well, or they did the same walk every day. Doubts were expressed about being able to walk back (as the picture showed a one-way walk) and what would happen if someone used a car to travel to where they would walk.

> *'No, I think that [map] would be a waste of time' Ppt 23, PwCOPD*

One PwCOPD said that they thought it would be useful to see what they had done on the map, and that this might make them do a bit more. Other participants identified other uses for the mapping function, such as finding people who were lost, or not getting lost themselves.

> *'It's on GPS, does that mean if you wander out and get lost, people would be able to find you?' Ppt 7, PwCOPD*

HCPs were a lot more positive about the maps being able to provide useful feedback; either due to past experience with a similar app themselves, or experience with some PwCOPD wanting as much information as they can get:

> *'They get back, they can have a look and think actually I really did just do that' Ppt 20 , HCP*

One HCP expressed doubts about whether the maps would be useful. Overall, despite using maps to provide feedback being a popular feature in mobile apps, the findings here suggest that with both negative and positive opinions expressed, the utility of maps to provide feedback may be decided by personal preference.

Figure 7.7: Rewards screen

Rewards in the form of stars and trophies, vouchers or donations to charity - Some PwCOPD thought that rewards would be a nice added extra, but that they would not add a lot of incentive:

> *'I wouldn't be doing it for any other reason…it's something that I'm doing to make my life better…I don't need someone to give me a reward' Ppt 7, PwCOPD*

HCPs echoed the sentiment that rewards and points are not the reason that someone would get involved in using a technology like this:

> *'They don't particularly need an incentive other than you're going to make them feel better' Ppt 12, HCP*

Some participants were in favour of the charitable donation, but warned that, as rewards were being given for self-set goals, this could result in people setting themselves easier goals to obtain points and rewards. One HCP found this approach childlike and paternalistic.

Summary

Activity	Walking
Date	September 5th
Distance	1.3 miles
Time spent	26 minutes 45 seconds
Calories	129 kcal
Weather	Partly sunny
Notes	

Figure 7.8: Summary screen

Summarising information - Counting calories was identified as useful by some PwCOPD and HCPs, distance was also identified by HCPs as useful due to distances often being a goal rather than time:

> *'I like how you broke it down into the distance they walked as well, rather than just the time' Ppt 15, HCP*

The use of summaries to cross reference was also identified as important, e.g., looking at 'a bad week' and using these summaries to identify aspects such as weather, symptoms, or how active a week was that may have caused it:

> *'[You could] put into the computer, I do feel better for having done them extra 500 [yards], Or I feel worse this week or whatever' Ppt 3, PwCOPD*

It was suggested by a HCP that the use of summaries might be better for more active PwCOPD.

Information that should be presented - Information that allows for easy comparison was commonly identified as important; this could be comparison between the level of performance and the goal, or comparison of performance today, with performance on previous days.

> *'They really like comparison' Ppt 12, HCP*

In the virtual coach (VC) scenario the feedback included a projection that showed when the user might reach their goal if they continue to follow the plan. One HCP identified this projection as useful. In addition to comparison it was thought that information related to distance travelled, calories burned, the weather, the temperature and the route might all be interesting to some users. However, for others, this level of detail might be seen as unnecessary. Some participants suggested additional information they would find useful, e.g. whether the walking they were doing provided health benefits.

'You know, whether I'm getting benefit from what I do you know as a hobby really you know but for my general health' Ppt 22, PwCOPD

Important features of a feedback display - The key points identified were that feedback should be clear, simple, and easy to understand. Two participants mentioned that FB5 (the flower display) would only appeal to a sub-set of people, and that this would make it an inappropriate choice. Participants identified the importance of personal choice in the opinions given towards feedback displays. For example, if the person had no previous experience of graphs, then it was thought that they may find graphs confusing. None of the participants had problems understanding at least one of the graphs. However, both HCPs and PwCOPD mentioned that, although they themselves understood them, not everyone with COPD would. How the feedback display was delivered was mentioned by some participants. One PwCOPD felt that it would be better to receive feedback on a larger screen than a phone, while three other PwCOPD said that they would prefer the feedback to be on a phone as it was more easily accessible. One PwCOPD expressed a preference for face-to-face feedback.

Displaying negative feedback – For one person with COPD, seeing a lack of activity graphically presented was thought to be motivating, therefore the clearer the graph was about the drop in activity, the better:

'[FB1] shows me very graphically that I've been a naughty girl' Ppt 9, PwCOPD

Whereas another PwCOPD remarked that seeing no activity would not affect him as he did not expect to do much activity. It could be speculated from these two opinions that a person's expectation of their level of activity might influence how they respond to feedback displaying no activity, but this would need further research to be supported. HCPs tended to prefer positive reinforcement and encouragement. It was argued that, as there might be a good reason for not doing the activity suggested, that there should not be any element of punishment:

'With the bar chart being blank...they know it's blank because they didn't do anything, whereas an angry face they might think, well, I know I didn't do anything, but it's not like I didn't want, they might have wanted to walk but they might have not been able to' Ppt 15, HCP

Goals

Three emergent sub-themes were identified related to goals; *Choosing an initial goal*, *Regulation of goals* and *Team goals*. Throughout this theme, participants discussed how active a role technology should take in someone's goal setting.

Choosing an initial goal – Opinion was divided about who should set the original goal. Some participants felt that having a goal suggested would be helpful, while others worried that the goal suggested would not be appropriate for them.

> *Sometimes you're better with somebody telling you what goal to achieve' Ppt 27, PwCOPD*

> *'I think people are more likely to do that if they can choose their own, whatever they want to do' Ppt 11, Carer*

Participants stated that the initial goal needed to be realistic in the user's eyes, and something that they would feel comfortable with, in terms of both their ability and activity preferences. Some participants felt that to achieve this, people would have to set the goals themselves, whereas other participants were happy for the technology to set the goal. Energy was seen by some PwCOPD and their carers as a limited resource, so it was better to do something useful, than to *just* exercise. For example, one carer mentioned that her husband (with COPD) became anxious if she did jobs that he would normally do. To avoid this it would be better for her husband to use his energy doing these jobs, rather than going for a walk or attending an exercise class.

> *'If you've a garden and you know it needs doing, you probably might not feel like doing it, so you've got to do your 30 minutes exercise today, are you going to go down to the shop, or are you going to get out there and do a bit of that gardening?' Ppt 28, Carer*

HCPs suggested that if PwCOPD set their own goals, they might set them too low, or find the process of setting goals too much of a burden, suggesting that it may benefit PwCOPD more if the technology set goals for them. However, a contradictory concern was raised that if the technology took on the role of goal setting, this would not be supportive of self-management. An initial set up with a HCP who knows the person with COPD, followed by PwCOPD managing themselves was suggested.

Regulation of goals – It was seen as essential that users received credit for making an attempt to reach a goal, and that they should not be discouraged if they didn't actually meet it. One person with COPD identified himself as competitive and said that, if the type of technology being described had been around when he had been more mobile, he would have enjoyed trying to beat the goals set over time. Other participants were more cautious and anxious to ensure that there would be the opportunity to change the goals in response to their own performance level, or the onset of illness. Some participants mentioned that people may do better than they think, and be able to move the goal upwards, but the majority of the views expressed were related to the need to reduce goals during times of ill health.

> *'If it's too much then you can cut back, you know you don't have to do that thing, if you can manage a bit of it fair enough and if it was too much, then cut down' Ppt 7, PwCOPD*

Some participants felt that the ability to regulate goals was so important that the goals and any changes to them should be wholly set by the user, and not by the technology. HCPs were more supportive of using the technology to set goals, as users would vary in how realistic they would be when they set goals for themselves:

> *'Having someone, or a system that's suggesting to them about continuing with their exercise and giving them ideas…about an appropriate level, an appropriate time to be exercising for is…quite useful' Ppt 29, HCP*

Safety was mentioned in terms of regulating the goals set and how the system would know when someone was doing too much, and whether there would be an alert for a sudden drop in activity. HCPs seemed confident that PwCOPD would stop if the technology set a goal too high, but less confident that PwCOPD would set goals that would provide an appropriate level of challenge for themselves. One carer felt that having the goals set by the technology, rather than the user, would mean that when her husband was ill over winter, he would be encouraged to do something, rather than nothing.

Team goals – The idea of contributing to team goals was not well supported by PwCOPD. One person indicated that the 'team' who started rehab together had not stayed together and so he didn't have much faith in that approach. HCPs were more positive, however, and felt that working towards team goals might take a bit of the pressure off an individual, and provide some extra motivation.

> *'I don't think it's as much pressure as the other one where you're on your own' Ppt 20, HCP*

One HCP mentioned that she felt motivated by the app she uses sending her an email with the cumulative mileage of everyone who has used the app, as she felt that she had helped to achieve this total.

Individuality

Two emergent themes *everybody's different* and *people who would use this type of technology* have been grouped under the theme *individuality.*

Everybody's different – Throughout the interview, participants mentioned that everybody is different and this was used as a qualifier for some responses. The identified ways that people were different included: age; personal preferences for feedback, and the use of music; past experience in terms of the technology they had used and their familiarity with graphs; and health in terms of the severity of COPD and other health related issues.

People who would use this type of technology – When asked about the scenarios, participants sometimes gave an impression of the characteristics of someone who they believed would be likely to use these systems.

> *'I would think that would come into the bracket for a younger person' Ppt 5, Carer*

Participants thought the systems would be useful for people who lived on their own:

> *'I can see people who are isolated getting on really well with that' Ppt 1, PwCOPD*

A carer and a HCP stated that people who were less active might spend longer on their computers and be more familiar with technology. However, PwCOPD in the current sample who were less active (e.g., due to poor mobility) felt that these systems would only be useful for those with better mobility.

Features

Audio – This theme covers the views expressed related to the audio encouragement given by the virtual coach and the ability to play music in the music and maps scenario. Generally, people were positive about both music and audio encouragement provided that it was the user's own choice of music. HCPs reported that, while music was popular in the gym, in their experience it is hard to please everyone, and that some people would prefer not to have music. It was thought by participants that music could distract the user from the physical activity, which was seen as a positive thing. However, there were concerns that wearing headphones could distract the user from the environment, in terms of safety, but also social interaction while walking.

> *'If you're walking on your own it's maybe not a bad idea, it occupies your mind a bit doesn't it? Ppt 18, PwCOPD*

> *'I prefer to be able to hear what's going off around me when I'm walking' Ppt 27, PwCOPD*

Virtual coach scenario – Some PwCOPD felt positively about the idea of a virtual coach, but thought that it would be more useful for someone less motivated than them. The virtual coach was thought to be good for people who are more mobile, and those living alone. Carers re-iterated similar sentiments; that it would be good for people who are mobile, on their own, and able to use the technology. HCPs were very positive, although they felt that the novelty of a virtual coach may wear off and not everyone would understand it. HCPs also felt that there should be an opportunity to simplify the virtual coach if the full system was too complex, but that the technology suggesting goals would be useful.

Reminders – The majority of participants were positively disposed toward the idea of incorporating reminders into persuasive technology:

> *'I think that would push you to do it, whereas you'd think oh I'll not bother today, but when you've got that little somebody pushing you, that little person' Ppt 26, Carer*

One PwCOPD mentioned that she doesn't carry her phone and her carer reminds her, so having reminders on the phone wouldn't be useful or necessary. The majority, however, felt that having reminders on the phone would be a good prompt and acknowledged that it was easy to become distracted and physical activity could easily be forgotten. HCPs thought that reminders might become annoying, so were keen to ensure appropriate personalisation in the form of being able to postpone reminders, or to have the option to switch the reminders off after 2 weeks or so. HCPs also mentioned that the act of choosing a time to complete the physical activity might be helpful as a form of planning, aside from the reminder when that time arrived.

> *'Thinking, well, I'm going to do it at 2 o clock, so I will do it at 2 o clock rather than saying, I'll do it in a bit, I'll do it in my own time' Ppt 15, HCP*

Music and maps scenario – Both PwCOPD and HCPs mentioned that music and maps were a good idea, but the system described in this scenario would not be enough on its own and goal setting from the virtual coach was suggested as a necessary addition to persuade people to perform the activity suggested. Again, the technology described in the music and maps scenario was thought to be better for someone with increased mobility and someone who walks outside, rather than someone who uses the gym. Some HCPs liked the music and maps system as it was similar to apps that they already used. However, they felt that the virtual coach system would be better for PwCOPD.

Online community scenario– Participants responses to the online community scenario were divided, with some participants saying that it was the most complex system and others saying that it was the simplest. One user had previously had a negative experience with an online support group and therefore said that they wouldn't use a technology like that again; another remarked that the success of online communities depended on who else was using the website. Across participants it was thought that an appreciation of the social components of this scenario would depend on the user's personality; that is, it may be important for some but wouldn't appeal to others. Participants who liked the online community scenario liked the potential for competition and for communicating with people who were going through similar experiences. Some participants said that the online community scenario would be better for those who are more mobile; while other participants thought that people who couldn't do anything else would be more likely to use such a technology. HCPs repeated this latter point, suggesting that the online community would be the best for people who cannot go out, but that this approach would only work if the user themselves chose it. One HCP said that it would be hard for her to 'sell' this system as she didn't like it.

Competitions – This PTT divided participants. Some PwCOPD felt that competition would motivate them and likened it to other competitive activities that they enjoyed like playing cards, or quizzes:

> *'It encourages you to do it both for your own sake and for the competition' Ppt 16, PwCOPD*

Others felt that incorporating competition would be associated with an aggressive desire to win and that losing may have a detrimental effect on someone's feelings; or that being in competition was not in keeping with the purpose of this technology (which is to increase self-management of COPD, and ultimately to feel better):

> *'Is making it competitive taking, taking the idea away from what you're actually doing it for?' Ppt 4, PwCOPD*

Some participants linked their own competitive nature to their opinion; some felt that being competitive would make losing harder, and others felt that being a competitive person would encourage them to try more. HCPs made the point that in rehab they try to discourage competition between people, as it can result in people over exerting themselves, or feeling disheartened. When the idea that the actual goal (i.e. how many minutes) would not be revealed to other users was re-iterated, some HCPs thought that was fine, while others felt that having hidden goals might encourage cheating and the rewards wouldn't necessarily go to the right people. One HCP didn't feel that any comparison of users would be appropriate in persuasive technology.

> *'We try and avoid encouraging that sort of behaviour, erm, and I'm quite a competitive person and you know the whole first person to get to 500 points and I would be, and I know this sounds really bad but I would be really inclined to decrease the amount of activity that I did to get my points quicker to beat someone' Ppt 29, HCP*

Social Support

Some people felt that computer mediated communication was not enough, and that they wanted face-to-face support in addition or instead of computer mediated communication. Others felt that it would be encouraging to be put in touch with other people who may have shared experiences. However, as mentioned above, one person did report a negative experience with an online community. Both PwCOPD and HCPs suggested that use of the social support aspects of the systems would depend on the user's personal preferences. That is, some people are social and would enjoy the social aspects of some PT systems, while others reported preferring to exercise alone, or that they would feel out of place in an online community. PwCOPD mentioned real-world support groups that they were a member of. It is notable that the scenario with the greatest number of social support components (online community scenario) was chosen as the most popular by PwCOPD.

Motivation

Motivation was mentioned across the interviews in relation to many of the other themes. This emergent theme draws together the key points made about motivation, in relation to physical activity and technology.

Carer as motivator – The role of the carer was mentioned several times in both dyadic and individual interviews. The impression given was that people with COPD do not need the system to replicate roles that the carer currently provides. For example, they don't need the system to motivate, if the carer motivates, and they don't need the system to provide social support if the carer provides social support. In these cases it was suggested that the system might be more suitable for people who live on their own, or who are not motivated.

> *'I've got [husband] to remind me as well remember, for anybody on their own that's good, but I've got cotton wool kid in there' Ppt 7, PwCOPD*

> *'If it was someone on their own who needed, because that is like me…I have to mosey [person with COPD] on a lot' Ppt 5, Carer*

Factors external to the system that motivate or de-motivate – This theme brings together comments relating to factors external to the system, which might influence a person's motivation to increase their physical activity. Knowing and experiencing the benefits of physical activity was thought to be a strong motivator. This was sometimes attributed to attending pulmonary rehabilitation. A local gym was also mentioned as providing help with designing an appropriate fitness plan, which the participant was then motivated to stick to. Having a goal in mind was thought to be important to provide motivation; this might be a desired activity, or a job that needs doing. External factors that were thought to negatively influence motivation were not being in the mood to do physical activity, and finding that the level of physical activity suggested was not tailored sufficiently. For example, an inappropriate environment, or an inappropriately high level of activity, was suggested. While this latter point could also be described as a problem of control (if the level is too high, then the person would be physically unable to do it), it may affect motivation to the extent that the person does not even want to try and strive towards the goal.

> *'If you can walk a mile, I'd love to be able to, because if you can walk a mile, you could walk a mile and 100 yards and if you can walk a mile and a 100 yards, you can then walk a mile and 200 yards, erm, but you need to be mobile…I am no longer mobile' Ppt 17, PwCOPD*

Other elements that affected the perceived level of control that an individual had over their level of physical activity were; fitting additional physical activity into daily routines, not losing track of time, pacing activities (or factoring in the rest that will be needed following exertion) and dealing with co-morbidities. Co-occurring health problems affected the opinions expressed in the interviews. For example, if people were unable to exercise due to leg complaints, or had difficulty using persuasive technology due to eyesight problems, then these problems qualified most answers given. All these factors when considered by the PwCOPD were found to decrease the motivation to try to increase physical activity. It was thought that some initial motivation to use the system would be needed, and that use of the persuasive technology should be monitored. HCPs referred to their experiences with pulmonary rehabilitation and described PwCOPD who, no matter how much you motivated them, would not take part. For these people it was though that persuasive technology in any form would not be effective. Conversely PwCOPD who described themselves as very motivated also said that these persuasive technology scenarios would not be useful, as they didn't need it. One HCP mentioned that beating her personal best on a persuasive app she used motivated her.

Features that motivate or de-motivate– This theme brings together comments made relating to specific features of the systems that might motivate people to increase their physical activity. It was thought that setting targets to aim for, reminders and the system being in accordance with certain personality traits of the users would all motivate some people. For example, one PwCOPD described the system as ‘geekish’ with the implication that this appealed to them. The use of competitions divided people as explained above. Monitoring, combined with following a set of rules (i.e. suggested goals) and playing games, was also thought to motivate use of the technology. Two people mentioned that being encouraged was motivating, and that encouragement from the technology would perform this function. Providing feedback using the map was not seen as particularly motivating. The provision of social support might be motivating, but two participants mentioned that only face-to-face support would do for this, and not computer mediated support. Points and rewards were not seen to motivate people as they could lead physical activity to be undertaken for the wrong reasons; feeling better was thought to be reward enough.

Preferences for scenarios

Preferences for all three scenarios were split almost equally overall (see Figure 7.7). However, the HCPs had a strong preference for the VC system over the others, while PwCOPD had a preference for the online community scenario. Carers who expressed preferences were divided between the online community and the music and maps scenario.

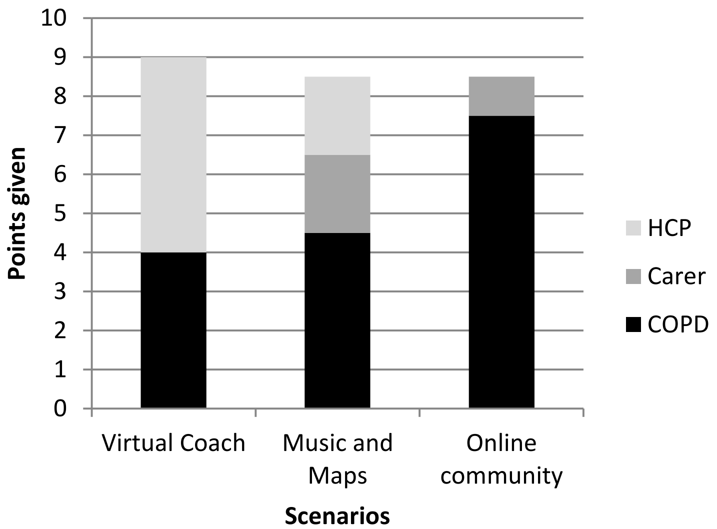

Figure 7.9: Preference for scenarios. One point was given if a participant chose a single favourite, 0.5 to each if a participant chose a combination of two scenarios

7.2 Survey Results

From 25/03/13 to 06/07/13 121 participants provided informed consent to participate in the study. Six then filled in no further information. Regrettably only 12 paper surveys were returned, so the planned comparison of findings between paper and online methods of completion was not possible. The Friedman tests described below were repeated using only the participants who completed the survey online and no significant differences were found, so the results presented here represent all participants regardless of mode of completion. The flow of participants through the survey is included in Appendix III. The results are reported as % of people who answered each question excluding those who either were not meant to answer the question, or who missed the question.

7.2.1 Background questions

Participants were 68% (76/112) female, aged between 43 and 82 with a mean age of 63.82 (*SD* = 8.51), 67% (75/112) lived in the UK, 28% (31/112) in the USA and the remainder from Australia (4%, 4/112), India and Belgium (1 participant from each; see Table 7.3).

Table 7.3: Survey sample characteristics

Characteristic		*% or Mean(SD)*
	Age	63.82 (8.51)
	Gender % Female	68
Country lived in	UK	67
	US	28
	Australia	4
	Other	2
MRC Grade	1	5
	2	24
	3	22
	4	29
	5	20
Current activity level	Days light activity per week	4.50 (2.38)
	Minutes light activity per week	513.23 (670.62)
	Days moderate activity per week	2.18 (2.33)
	Minutes moderate activity per week	258.96 (497.15)
	Days vigorous activity per week	1.25 (2.12)
	Minutes vigorous activity per week	72.81 (105.39)

COPD

The modal MRC breathlessness grade was 4 which is represented by the need to 'Stop for breath after walking about 100 yards or after a few minutes on level ground' although more than 20% of participants chose MRC breathlessness grades 2, 3, 4 or 5 indicating a spread of breathlessness within the sample. The time since diagnosis ranged from 4 months to 48 years with a mean of 8.61 years (*SD* = 4.00).

Current physical activity levels

Participants were reasonably active with 61% (42/69) of participants exercising at or above the current government guidelines of 150 minutes of moderate activity per week. Despite this, 76% (85/112) of the participants reported wanting to do more physical activity. Of the barriers given to doing more physical activity, 70% (64/ 91) of participants selected 'I get breathless' (see Figure 7.10).

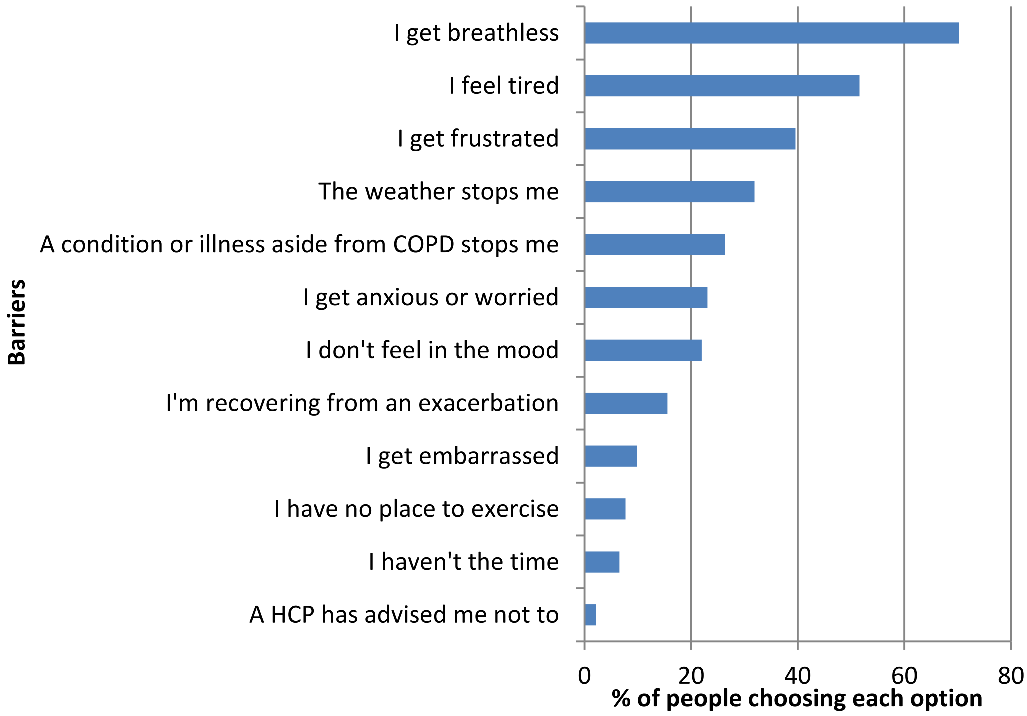

Figure 7.10: Barriers to performing more physical activity

Technology use

Technology use in this sample was high, with 93% (104/112) reporting using a computer; with 85% (88/104) of these responding that they used a computer 'multiple times per day'. The most commonly chosen uses for the computer were using email, getting health related information and using online support groups (see Figure 7.9 for breakdown of uses for the computer).

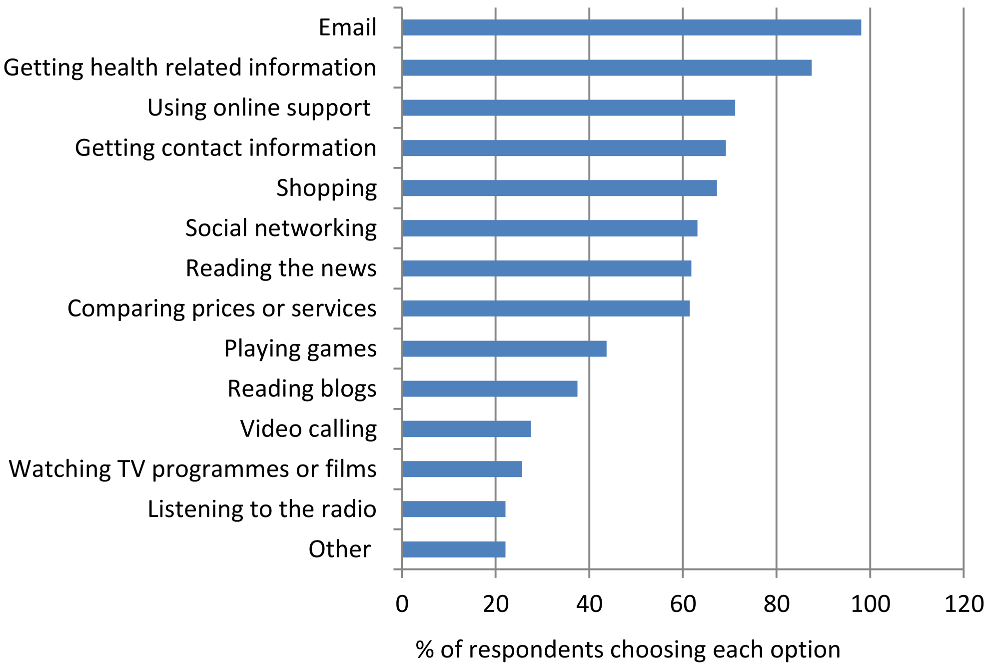

Figure 7.11: Uses of the computer (n=104 participants asked to tick all that apply)[13]

Mobile phone use was slightly lower than computer use with 86% (96/112) owning a phone, and 43% (41/95) responding that they used their phone multiple times per day. 58% (55/95) of participants reported that their phones could access the internet, however only 28% (27/ 96) of participants reported using their phone to access the internet. Calling (88%, 84/96) and texting (69%, 66/96) were most frequently reported (see Figure 7.11). When asked about persuasive technology, 43% (48/112) of participants said that they had heard of it, 51% of these participants (26/48) had used persuasive technology and of these participants 58% (15/26) were currently using persuasive technology. In some cases the description given was of

[13] Uses if a computer listed in 'other' were: To use internet banking (*n*=6), to assist with volunteering (*n*=4), for work (*n*=3), to get family history information (*n*=2), to watch exercise videos (*n*=1), to get information about hobbies (*n*=1), to get legal advice (*n*=1), to edit photos, to write blogs (*n*=1), to download eBooks (*n*=1), to buy tickets (*n*=1), and to complete surveys (*n*=1).

a non-interactive technology such as watching video exercises, or looking for information online (n = 8), but other participants reported using apps to track exercise (n = 10), stop smoking (n = 8), access support groups (n = 8), eat healthily (n = 7), lose weight (n = 4) and to self-manage their COPD (n = 1), or participants mentioned non-specific phone or iPad apps (n = 3). Additional devices were also mentioned. Three participants mentioned using a Fitbit device (a pedometer that links with software to track steps) and one participant reported using technology to monitor their blood pressure and pulse.

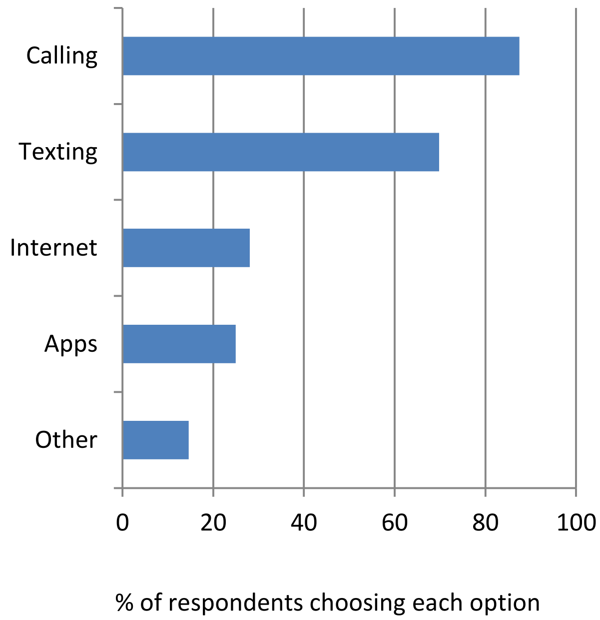

Figure 7.12: Uses of a mobile phone (n=96 participants asked to tick all that apply)[14]

Most of the participants that reported using persuasive technology mentioned more than one type. When asked whether participants would consider using persuasive technology if they wanted to change their behaviour in the future, 60% (58/96) responded yes, 18% (17/96) responded no and 22% (21/96) responded that they didn't know. Similar reasons given for considering using persuasive technology were grouped:

The opinion that anything that might help was worth trying (n = 15):

> *'Why Not? It might work...' Ppt ID72*

The ease of access (n = 6):

[14] Uses of a mobile phone listed in 'other' were: For safety (n=7), to stay in touch with family and friends (n=3), for work (n=1), to use email (n =1), as an alarm clock (n=1) and to use global positioning satellites (GPS, n =1)

'Easier to access information on line and more convenient' Ppt ID120

The opinion that persuasive technology might motivate participants to become more active (*n* = 5):

'Encouragement on a computer would help, advice would be benifical [sic]' Ppt ID95

As a reminder (*n* = 2):

'Would be useful to have reminders' Ppt ID86

And to keep track of physical activity (*n* = 2):

'To keep a log, keep track' Ppt ID80

Two participants mentioned that persuasive technology would need to be interactive if they were to consider using it and one reported that the persuasive technology would need videos to be included in it:

'If some sort of interactive style input [was] available then I think it would help' Ppt ID33

Other responses included general opinions that persuasive technology might improve health (*n* = 1) or help the participant to lose weight (*n* = 1).

The reasons given for not considering using persuasive technology were:

Technology was not needed, as the participants were happy with their health behaviours (*n* = 5):

'I never smoked and I already exercise at a gym. I do Pilates with a personal trainer. I already eat a healthy diet' Ppt ID75

Or participants felt that they already had the necessary information/support to make changes (*n* = 2):

'I already know what I must do to maintain my current health status.' Ppt ID68

Three participants expressed concerns about the complexity of persuasive technology:

'Things can get too complicated for me' Ppt ID3

And three participants mentioned that using persuasive technology would involve spending too much time on the computer, which was not considered to be healthy (n = 3):

'I don't think looking at a computer screen or a phone is good exercise' Ppt ID6

Two participants thought using persuasive technology might be boring:

'Could be boring on your own' Ppt ID20

One participant questioned the validity of the persuasive technology that is currently available and finally, one participant expressed a preference for human contact rather than using persuasive technology.

7.2.2 Opinions and preferences towards persuasive technology

Perceived persuasiveness of the scenarios

Perceived persuasiveness was measured on a scale with a possible range of 8 – 56 for each scenario (8 items, scored 1-7). The virtual coach scenario (VC) was scored highest (see Figure 7.13) *Mean* = 40.66 (*SD* = 11.51), followed by the music and maps (MM) *Mean* = 37.51 (*SD* = 11.69) and the online community (OC) *Mean* =30.55 (*SD* = 14.28). The Friedman test identified a significant main effect of scenario (χ^2 (2) = 28.19, $p < 0.001$). The Wilcoxon signed rank test (with Bonferroni correction of 0.05/3 applied to the p value necessary for statistical significance) was conducted and found significant differences between all three scenarios; VC and MM ($Z = -2.83$, $p < 0.015$); VC and OC ($Z = -5.53$, $p < 0.015$); and MM and OC ($Z = -3.94$, $p < 0.015$).

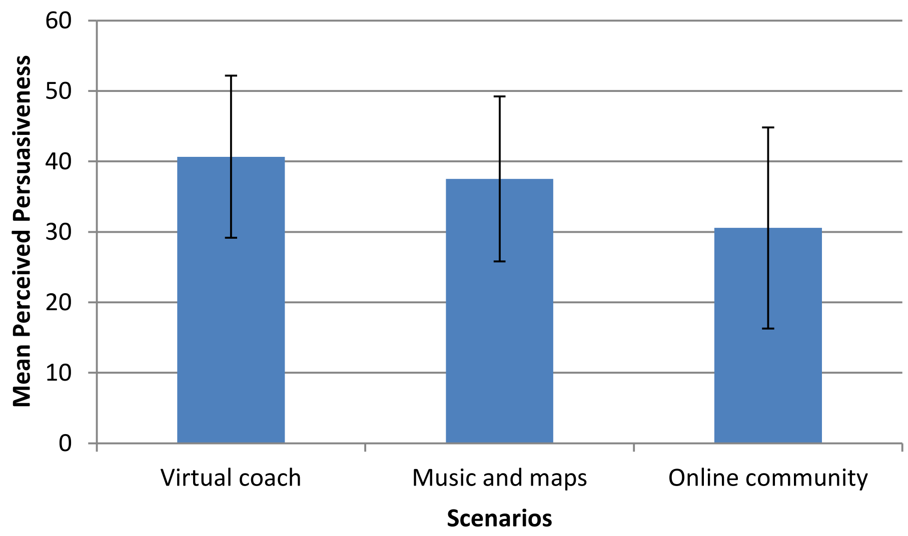

Figure 7.13: Perceived persuasiveness by scenario

The content of the 'Other comments' box was categorised as positive or negative for each scenario. Negative comments included comments that participants made about the scenario being unsuitable for them, even if they indicated that it might be suitable for others.

Making additional comments about the scenarios was optional, and 64 participants made a comment on at least one of the scenarios. The comments received were more negative than positive for all three scenarios (VC scenario: 39 negative comments to 15 positive; MM scenario: 36 negative comments to 15 positive and OC scenario: 35 negative comments to 20 positive). Negative comments related to the technology (27 comments) and the activity levels suggested (14 comments) were made in response to all three scenarios. These comments related to the participants not owning the necessary technology:

> *'The technology relies on a smart phone.' Ppt ID49, OC scenario*

In some cases there were concerns about the running costs if a phone was connected to the internet:

> '*Having to use your mobile phone would prove expensive' Ppt ID72, VC scenario*

Finally, some participants expressed concern about using technology generally:

> *'I can think for myself. [I] don't need technology' Ppt ID94, MM scenario*

The comments about activity levels either expressed that, as the participant had very low activity levels, none of the scenarios would be useful:

> *'As I cannot get out and about this would be absolutely useless to me' Ppt ID6, MM Scenario*

Or, because their activity levels were high, persuasive technology was not needed by them:

> *'Interesting but not for me. I already walk my dog every day'. Ppt ID90, VC scenario*

In most cases participants who expressed the latter opinion described the system as being useful for others, but not themselves:

> *'This could be useful to many COPD patients I know. Again, I probably wouldn't use it since I have a routine that sends me to the gym every day.' Ppt ID 44, MM scenario*

Scenario specific negative comments were also made related to not liking the idea of a virtual coach:

> *'It insults the intelligence to suppose some stick figure would make a difference to motivation or ability to achieve' Ppt ID6, VC scenario*

Or not liking the way that the coach was represented:

> *'Didn't like that the 'coach' was bowlegged - didn't seem like a healthy example. A bit too cartoony for me'. Ppt ID71, VC scenario*

Some participants did not think that the maps were useful in the MM scenario:

> *I don't consider the mapping function very useful. I walk where I am already familiar with the area' Ppt ID49, MM scenario*

Or did not like the idea of listening to music while exercising:

> *'I don't believe in walking with headphones on as it seems dangerous to me!' Ppt ID91, MM scenario*

And finally, the competition aspect of the OC scenario was thought by some participants to be unacceptable:

> *I am end stage. I cannot even dress myself. Why would I want to be in competition with others? My self-esteem would plummet every time I 'failed'' Ppt ID6, OC scenario*

Positive comments were also made about the three scenarios, with some participants liking the idea of the coach:

> *'I particularly liked the part where the coach could send you encouragement while exercising to help you reach your goal.' Ppt ID 23*

Some participants stated that the interactive nature of the VC scenario would be an advantage:

> *'I liked the interaction with the mobile phone on the walk.' Ppt ID31*

For the MM scenario the positive comments related to the maps and music elements

> *'I like the tracking & logging functions as well as the music. The reporting on the PC is great'. Ppt ID64*

Finally some participants were positive about the potential for competition to be an effective technique in the OC scenario

> *'I like the idea of competing with and against others' Ppt ID75*

While others focussed more on the social support aspects of the OC scenario:

> *[The OC scenario] is the best of the three scenarios, IMO [in my opinion]. Having others to chat with and discuss exercises done might be fun.' Ppt ID70*

Feedback scores

The feedback screens were rated on a scale with a possible range of 4-28 (4 items, scored 1-7). FB2 was given the highest score by participants *Mean* = 21.77 (*SD* = 4.76), followed by FB1 *Mean* = 19.35 (*SD* = 5.07), FB3 *Mean* = 18.75 (*SD* = 5.44); FB4 *Mean* = 18.67 (*SD* = 5.30) and finally FB5 *Mean* = 13.93 (*SD* = 5.81). The Friedman test showed that screen had a significant main effect on feedback score χ^2 (4) = 93.43, $p < 0.001$. Wilcoxon signed rank tests were conducted with a Bonferroni correction for multiple comparisons (significance accepted at a p<0.005 level). There was a significant difference in the feedback score given between: FB1 and FB2 $Z = -4.21$, $p < 0.005$; FB1 and FB5 ($Z = -5.68$, $p < 0.005$; FB2 and FB3 $Z = -4.67$, $p < 0.005$); FB2 and FB4 ($Z = -5.08$, $p < 0.005$); FB2 and FB5 ($Z = -7.32$, $p < 0.005$); FB3 and FB5 $Z = -5.87$, $p < 0.005$; and finally FB4 and FB5 ($Z = -6.59$, $p < 0.005$). To summarise FB2 (which was scored highest) had a significantly higher score than all the other screens and FB5 (which scored lowest) had a significantly lower score than all the other screens; FB1, FB3 and FB4 did not have significant differences between them.

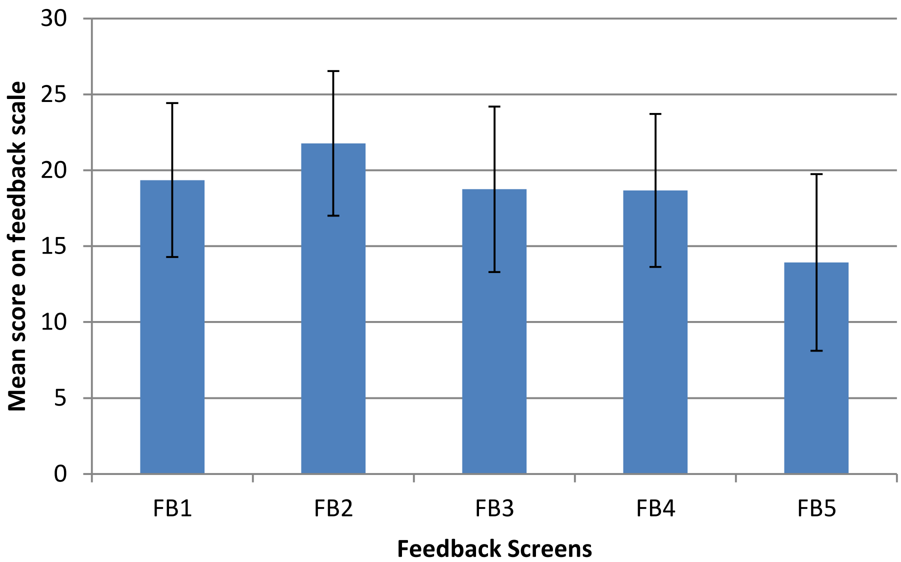

Figure 7.14: Feedback screens mean scale score with SDs.

Ranking individual persuasive technology techniques

57 participants ranked at least 5 features of persuasive technology. The ranks were reversed so that the feature given 1st place was scored as 5 and the feature given 5th place was scored as 1. The feature that received the highest score was 'Tips and advice on performing activity with COPD' (see Figure 7.15). The features were then sorted according to the element of the persuasive systems design model that they addressed; primary task support (*Mean* = 3.55, *SD* = 6.31), dialogue support (*Mean* = 4.15, *SD* = 5.61) or social support (*Mean* = 1.84, *SD* = 3.88). The Friedman test identified a significant difference between the elements of the persuasive

systems design model ($\chi^2(2) = 16.22$, $p < 0.001$). The Wilcoxon signed rank test (with Bonferroni correction of 0.05/3 applied to the *p* value necessary for statistical significance) was conducted and found features associated with primary task support were rated significantly higher than those associated with social support ($Z = -3.85$, $p < 0.015$); features associated with dialogue support were also rated significantly higher than those associated with social support ($Z = -3.37$, $p < 0.015$); but there was no significant difference between features associated with primary task support and those associated with dialogue support ($Z = -1.16$, $p = 0.25$).

7.3 Integrated discussion

A matrix was designed to integrate the findings from the interview and the survey studies (see Section 6.2.6). The rows included topics from the background questions, the opinions of the scenarios, the opinions of the feedback screens and the preferences for scenarios, individual features, or techniques, and feedback screens. The columns were data from the interviews, data from the survey and comments of the integrated data. A copy of the matrix is included in Appendix III. Confirmatory, expansive and discordant findings were identified. This section will discuss these integrated findings before presenting the limitations of this study and the conclusions.

7.3.1 Background questions

The sample included in the survey included the complete range of breathlessness as measured by MRC breathlessness grade. However, they included a greater proportion of those with higher levels of breathlessness than the general population of people with COPD. In a study assessing the levels of breathlessness reported by 40,425 people with COPD cared for in primary care (Müllerová, Lu, Li, & Tabberer, 2014), the following MRC grades were reported (the percentages found in the sample reported in this survey results are reported in brackets for comparison): 18% (5%) reported MRC grade 1 (the lowest level of breathlessness); 38% (24%) reported MRC grade 2; 26% (22%) reported grade 3; 14% (29%) reported grade 4; and 3% (20%) reported grade 5 (the highest level of breathlessness; Müllerová, Lu, Li, & Tabberer, 2014). Although the MRC breathlessness grade was not measured in participants who took part in the interviews, 69% of the sample reported having trouble walking outside and 38% used oxygen, which suggests that the participants who were interviewed had at least moderate symptoms of COPD. The method of recruitment used in the present study (through online and face to face support groups) could have resulted in fewer PwCOPD with mild symptoms than in the general population of PwCOPD. Potentially people with COPD would not join a support group if their symptoms were very mild, and may be more likely to seek help if their symptoms were more severe.

Figure 7.15: Sum of ranks given to individual techniques and features

The level of physical activity reported by the participants who completed the survey was relatively high with 61% of participants meeting the guideline amounts (150 minutes per week of moderate intensity/ 75 minutes per week of vigorous intensity or an equivalent combination of vigorous and moderate intensity activity). This is surprising considering the high levels of breathlessness reported. It is difficult to obtain a precise figure for the prevalence of older adults who meet the physical activity guidelines for comparison. In a recent systematic review, several factors were identified that made calculating a precise estimate a challenge: the different guidelines used by primary authors; the differences between objective and self-report measures of activity; and the differences in what activities were classified as physical activity (Sun, Norman, & While, 2013). The percentage of the older adult population who achieve levels of physical activity at or above the national guidelines was reported in this review as between 2.5% and 83% (Sun et al., 2013). The Health Survey for England 2012 reported that 55% of the general population of adults aged 55-64 were meeting the guideline amounts of physical activity. Surprisingly, this percentage increased for males aged 65-74 (to 58%) and dropped for women in the same age group (to 52%). For adults aged 75-85, 43% of men and 21% of women met the guideline amounts of physical activity (Scholes & Mindell, 2012). The sample of PwCOPD who completed the survey, therefore reported being more active than the general population of older adults in England. It could be speculated that PwCOPD may be more likely to receive advice from a health professional to increase their levels of physical activity, and therefore be more active than the general population. Alternatively, the sample of PwCOPD recruited here may be more active than the population of PwCOPD as a whole. Finally, as this finding is based on self-reported activity, it could be that this sample is over-reporting their activity levels. Without national statistics describing the level of physical activity undertaken by people with COPD, or objective measures of activity, deciding between these explanations is difficult.

As might be expected from a sample who agreed to take part in research relating to technology, the level of technology use was relatively high; with the majority of the participants owning a mobile phone. In addition, technology use amongst the survey sample was higher than those participants who were interviewed, and this again would be expected as the majority of surveys were completed online. In the most recent report from the Office of National Statistics, 67% of people in England aged 55-64 and 37% of adults aged 65+ used a computer at least daily (Office for National Statistics, 2013). In the survey data reported here, 85% of participants used the computer multiple times per day. The same ONS report suggests that 9% of those aged 65+ and 29% of those aged 55-64 used their mobile phones to access the internet. The overall proportion reported in this survey was 28%. Split into the same age brackets as the ONS survey, the proportion of people 65+ who reported using their phone to access the internet in this survey was far higher than the general population (26% compared to 9%), whereas the proportion of those aged 55-65 was a little lower in this sample (24% compared to 29%).

In summary, the sample recruited here may not be representative of PwCOPD as a whole. They may have greater levels of breathlessness, higher levels of technology use and the survey sample may have higher levels of physical activity. The qualitative data suggested that participants' current level of activity might have an effect on their opinion of the persuasive technology, however this could not be tested quantitatively. A larger number of participants may have resulted in normally distributed data, and homogeneity of covariance to meet the assumptions of a mixed ANOVA; which would have allowed this analysis. The current findings should be interpreted in light of these sample characteristics and, while generalizable to comparable PwCOPD, caution should be used if generalised beyond this.

7.3.2 Opinions and preferences towards persuasive technology

Overall there was support for using persuasive technology. The participants who were interviewed were generally positive and, in the survey, none of the scenarios had an average score below the halfway point on the scale of perceived persuasiveness. However, there were relatively wide confidence intervals for the scores given to all three scenarios and a greater number of negative comments were made than positive, indicating that some participants completing the survey felt negatively about them. The interview data in this case provided expansive explanatory detail. Important caveats were mentioned to qualify the positive opinions given. It could have been that without the opportunity to clarify, and identify caveats, those participants completing the survey expressed their opinions more negatively.

The caveats identified by those interviewed related to users' existing familiarity with technology, levels of motivation, and their levels of mobility. It was thought that existing motivation, both to use the system, and to increase physical activity, would be needed. Pre-existing motivation has previously been identified as important in younger adults' perceptions of health related apps (Dennison, Morrison, Conway, & Yardley, 2013). The necessity to tailor the system based on users' current level of mobility and presence of co-morbidities, as well as to personalise the system according to tastes and interests, were also frequently mentioned. The effect of these characteristics were described more as preventing the use of persuasive technology than facilitating it; rather than describing , someone with good mobility, with previous experience of technology being *more* likely to use the persuasive technology, it was more often described that people lacking in technology experience, mobility and/or motivation would be *less* likely to use persuasive technology. The impression given was that these characteristics would prevent any form of persuasive technology being used for this purpose.

To summarise these findings, the hypothesised influences on initial interest in persuasive technology are shown in Figure 7.16. In both the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) and the persuasive systems design model (PSD; Oinas-Kukkonen & Harjumaa, 2009), the importance of certain pre-existing personal characteristics, and characteristics of use, are identified that will affect how a person interacts with a technology and, in turn, how their behaviour may change. The hypothesis is that the same technology presented to different people, in different circumstances will have different effects. In the UTAUT the pre-existing characteristics of potential users affect: *performance expectancy* (how likely it is thought that using the technology will result in the desired outcome); *effort expectancy* (how hard it is thought to be to use the technology); *social influence* (whether other people who are important to the user think that they should use the technology); and *facilitating conditions* (similar to the context of use in the PSD, some situations would be more likely to encourage technology use, others less so). The findings of Study 4 describe people with low levels of ability to be physically active, as likely to think that they were not mobile enough for persuasive technology to be any use to them. This could suggest that their level of ability influences performance expectancy. However, if a person did not have an interest in increasing their physical activity then the use of technology would not change this. It could, therefore, be hypothesised that level of ability (both perceived and actual) could influence motivation to be physically active, which in turn could influence the performance expectancy.

In a parallel process, previous experience of technology was thought to be important as the concern was raised that a lot of people would be unable to use the technology. This concern could relate to a person's expectancy of perceived effort i.e. if using the technology was seen as *too hard* for them their effort expectancy would be high. Effort expectancy again however, could be hypothesised to be affected by a person's interest, in this case to use technology. The findings from Study 4 identified how complex the technology was thought to be as a key factor in encouraging initial use, with repeated mentions made to the importance of *keeping it simple* made in the interviews. This suggests that if the technology was viewed as complex (high effort expectancy), this may also affect how likely people thought it was that using the technology would have a positive effect (performance expectancy). While initial interest in both using technology and increasing physical activity would be necessary, they would not be sufficient; if the desired effects were not thought to be likely (low performance expectancy) or the technology was thought to be too complex (high effort expectancy), the user would still not be interested.

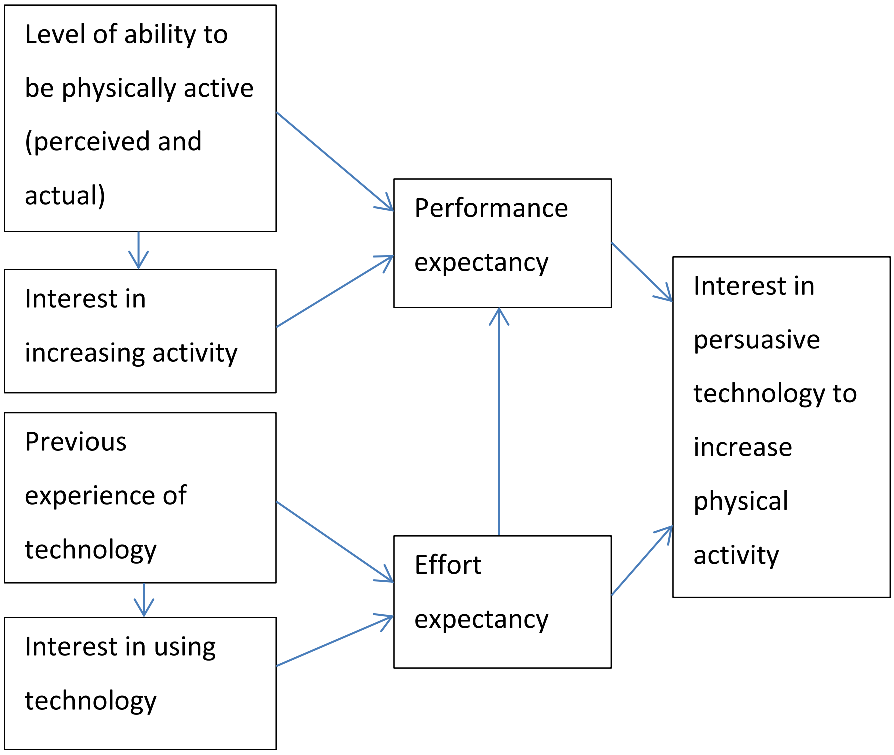

Figure 7.16: Hypothesised factors that may influence interest in the use of persuasive technology

The model proposed in Figure 7.16 could provide some useful approaches to interventions. For example, if a potential user expressed that they did not feel that using the technology would increase their activity (low performance expectancy), the reasons for this could be investigated. They may need further information and/ or persuasion that the system would lead to increases in physical activity, or that they are capable of using the technology, and of doing the activity. Alternatively, it could be that the user's past experiences with technology have been negative and resulted in frustration; this could affect the effort expectancy negatively, and in this case the user's attitudes towards technology as a whole may need to be challenged, by showing how this technology is easier to use.

Scenarios

Three scenarios were presented to participants that used different categories of persuasive technology techniques i) a virtual coach scenario that utilised features such as praise and suggestions; these have been defined as dialogue support techniques in the PSD as they aim to encourage a social interaction between the technology and the user (Oinas-Kukkonen & Harjumaa, 2009); ii) a music and maps scenario that did not encourage social interaction, instead it provided only primary task support techniques to assist the user in increasing their physical activity and iii) an online community scenario that enabled interaction with other PwCOPD through the use of social support techniques. These scenarios differ in the level of involvement, and the role that technology would have in PwCOPD's behaviour change. The relationship between the categories of PTTs and BCTs drawn from control theory are outlined below and summarised in Figure 7.17.

The interview data showed that there was some discrepancy between PwCOPD's and HCPs' opinions about the appropriate role for technology. HCPs identified the virtual coach scenario as their preferred option and expressed a preference for technology to provide greater dialogue support features and take a more active role in encouraging, praising and motivating participants through suggestions and reminders. One of the dialogue support PTTs *reminders* were repeatedly mentioned in the interviews and thought to be motivational and were ranked 6th out of the features by those who completed the survey. This suggests reminders were popular with this sample, but they are not very frequently used in the most downloaded apps. Some HCPs stated that they did not think the primary task support techniques used in the music and maps scenario would be enough, and that users would need supported goal setting and encouragement. The opinions of PwCOPD who were interviewed however were more evenly distributed across the three scenarios, with a slight preference for the online community scenario, which facilitated social support from other people with COPD. In the survey data, the virtual coach scenario was rated as most persuasive, followed by the music and maps scenario and finally by the online community scenario. In addition, the analysis of preferences for individual features (not within the scenarios) indicated that both primary task support and dialogue support features, were ranked significantly higher than social support features. In terms of PwCOPD therefore the findings related to the online community scenario were discordant, with those PwCOPD interviewed preferring it to the other scenarios, and those PwCOPD who completed the survey rating it the least persuasive, in agreement with the HCPs who were interviewed. This is especially interesting as largely participants who completed the survey were recruited through online support groups, so it might have been predicted that the survey respondents would be pre-disposed to think positively of this scenario.

In the current literature, primary task support elements are found most frequently in apps that aim to reduce smoking and drinking, and those that target weight loss (Lehto & Oinas-Kukkonen, 2011). The authors of this study have argued that increased use should be made of dialogue support techniques and this would support the present research (especially the inclusion of reminders). In an analysis of a website that aimed to support weight loss and increase positive mood, dialogue support features were shown to have a direct effect on perceived persuasiveness as well as an indirect effect through perceived credibility. Perceived persuasiveness was then found to predict intention to use, then actual use of the website. Primary task support was only found to have an indirect effect on perceived persuasiveness through dialogue support (Drozd et al., 2012). Future research should investigate these relationships further, and identify effects of dialogue support techniques in promoting increases in physical activity with PwCOPD, as they seem to be acceptable to this population.

To explore the discordant finding in more depth, the competition element of the online community scenario divided opinion among participants in both the interviews and the survey. Some PwCOPD felt that competition would be encouraging, while others felt that the danger of becoming disheartened was too great, and that any system should aim to provide positive support and encouragement only. This opinion was echoed by the HCPs that were interviewed. Unlike rewards and maps, that were thought to be potential *nice extras* that might be ignored, HCPs seemed to recognise that competition could be persuasive, and felt that this level or approach to persuasion was inappropriate. It has been found that when users set goals for themselves, the *anticipatory emotions* that are elicited can have an impact on the amount of effort that is put into trying to achieve the goal (or goal striving; Bagozzi & Pieters, 1998). For some of those interviewed, the competitive element was compared to other competitive activities they enjoyed such as playing cards or quizzes. For these participants, perhaps the anticipated emotions would be positive, as competition is seen as fun. Other participants however may have anticipated a fear of failure, so would have reacted negatively. In the PSD, the competition technique is reported to operate 'by leveraging human beings' natural drive to compete' (Oinas-Kukkonen & Harjumaa, 2009, p.495), and the inclusion of competitive elements has been found to have a positive effect on effect sizes in a meta-analysis of physical activity interventions among healthy adults that are not technology specific (Conn, Hafdahl, & Mehr, 2011), as well as being frequently used in weight loss apps (Lehto & Oinas-Kukkonen, 2010) and physical activity apps (as reported in this thesis). In this case however it could be suggested that the link between the physical activity and COPD infuses competition with stronger emotions. Those PwCOPD who appreciate the importance of physical activity may connect failure to be active with decline in their health and therefore the consequences of not succeeding in the competition may be viewed as more serious.

The competition element in this case was provided alongside other social support techniques. The role of technology in providing social support was identified by those PwCOPD, who were interviewed, as especially useful for people who do not have social support at present. This could explain why PwCOPD, who were already members of an online support group, did not rate the online community scenario as highly the others. Their existing membership of a similar group may have negated the need for an online support group in relation to a physical activity persuasive technology. While all the participants were members of a support group, the face to face Breathe Easy groups only meet once a month, whereas the online groups are available at any time. This could indicate that those PwCOPD who were interviewed would gain greater benefit from the social support aspects of this scenario, whereas this need was met in the majority of those who completed the survey. This idea could be assessed in future research by exploring the level of social support PwCOPD have available. In future research it would be advantageous to assess the effectiveness of the competitive elements that are offered in many physical activity apps for the general public, and perhaps investigate the emotional reaction elicited by them in both the general public and PwCOPD. It could be that there are differences within each of these groups, with members of the public liking some features of the apps they download, and not using others.

Feedback

Regarding the specific features of the scenarios and the five feedback screens, the results found in the integration could be described as expansive. Similar findings were reported by both samples, with further explanation of the online findings available from the interview data. FB2 (the bar chart showing the comparison of goal and amount of activity) was found to be the most popular in both cases, and FB5 (the flowers) the least popular. Data from the interviews provided additional information on why this might be the case, and identified the important components of a feedback display for PwCOPD. The interview data identified that feedback should be clear and simple, provide information about comparisons (behaviour over time as well as behaviour compared to goals), and that it should not highlight the negative, but try to focus on the positive aspects of trying if the goals are not reached. In a recent review paper, the role of affect in receiving feedback is explored; when faced with the feedback that the performance has not reached the goal, it is accepted that people will feel negative. However, if they feel frustrated and angry this may result in increased effort to reach the goals, whereas feelings of sadness and depression are thought to be more correlated with giving up on the goal (Mann et al., 2013). It is acknowledged by Mann et al., that there is little evidence related to this hypothesis from a health setting however it may provide an explanation for the different reactions to bad news shown by this population.

The persuasive technology techniques associated with feedback that were used in many of the apps available for the general public such as rewards, maps and summaries were not particularly popular amongst those interviewed and in the surveys; *seeing a map of the walk* *you have done* was ranked about half way through the list of features, but all those related to points or rewards appeared low in the ranked list (see Figure 7.8). Rewards could be seen as an external motivation, encouraging users to complete the goals, or interact with the system in order to receive the points. It has been found in a meta-analysis that increases in external motivation correspond with decreases in intrinsic motivation, and this relationship was found whether rewards were related to performance, completion or simply engagement (Deci, Koestner, & Ryan, 1999).

Goal-setting

The idea that PTT systems might provide reminders and suggestions of goals was positively received by the majority of the stakeholders who were interviewed. This was thought to be appropriate provided that there was the option for the users to adjust them, and the goals chosen were realistic and attractive in terms of ability and interests. As discussed above HCPs in particular were keen for technology to have a more active role in persuading PwCOPD to be more physically active. In the survey however the feature *setting own goals* was ranked higher than *goals suggested by the system.* As in the above discussion of overall opinions of persuasive technologies, this could be because in the survey no caveats could be identified. If the PwCOPD who completed the survey shared the concerns expressed in the interviews towards the technology setting inappropriate goals, as there was no way to express this, this may have resulted in this feature receiving a lower score. Although not wholly conclusive (and may be a matter of individual preferences), the findings related to goal-setting provide greater detail about how persuasive technology and behaviour change techniques might work together in the context of promoting physical activity among PwCOPD. The achievement of a goal that is set too low is dissatisfying, as is the failure to achieve a goal that has been set too high (Mann et al., 2013). The present research gives some indication of the ways in which a goal should be made appropriate for this population; in terms of setting, level and individual interests. Only if this could be achieved by a persuasive technology system, would people accept a technology suggesting goals. Appropriate goals may be more intrinsically motivating for an individual as they are perceived as more personally relevant, and intrinsic motivation has been found to be a key determinant of successful goal striving (Deci & Ryan, 2008)

Participants in the current study emphasised the importance of being able to review and change their goals over time. As discussed in Chapter 5, the ability to self-regulate goals is key to maintaining physical activity. Links could be drawn between the way the participants in this study described self-regulating their goals and performance expectancy. For example, if a user had an exacerbation (sudden worsening of symptoms) it was identified as important that they could set lower goals, otherwise their level of physical capability compared with a high goal would mean that the user would not believe they could achieve it, and this would decrease their motivation (Playford et al., 2009), and their expectancy that using the technology would lead them to achieve their goal. Whereas, if the goals were incremented slowly, and matched to the user's current level of ability (daily if necessary), this would be more likely to support the user in the gradual increase of their physical activity, providing challenging, but achievable goals (Locke & Latham, 2002).

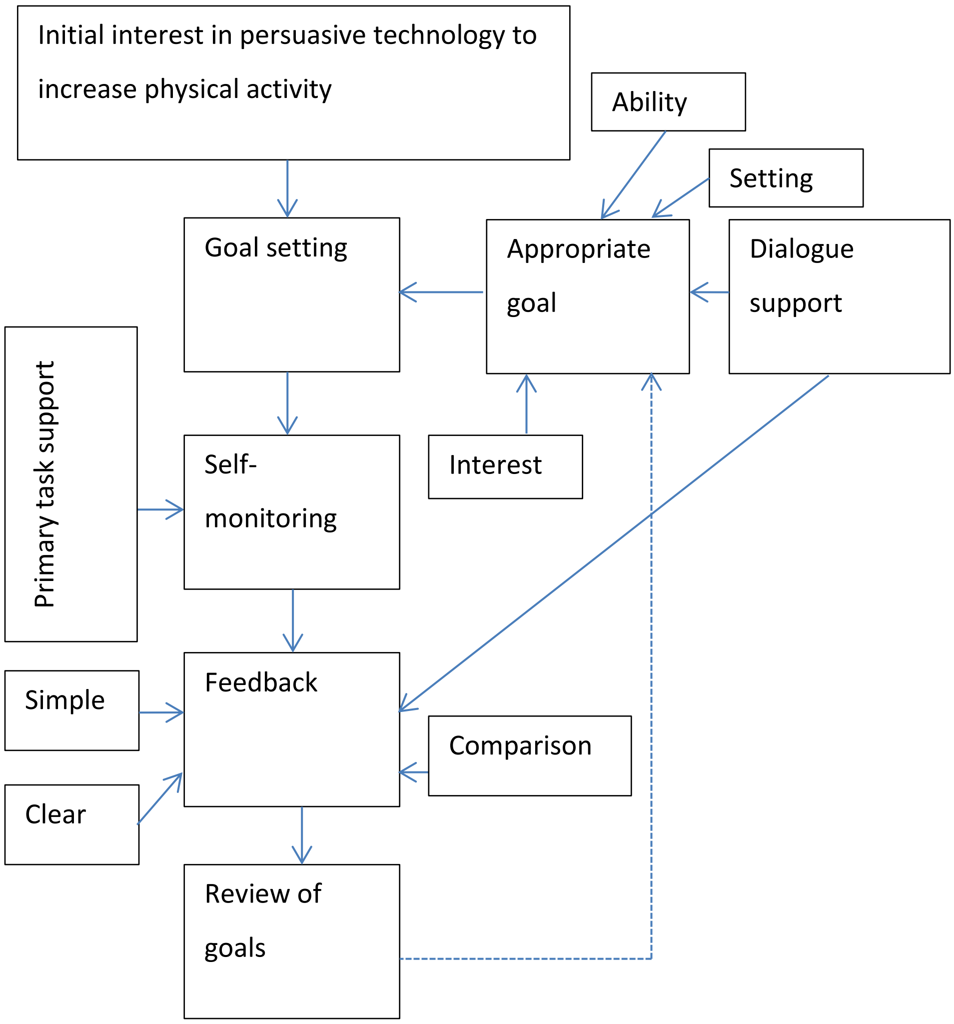

Figure 7.17: Hypothesised relationship between persuasive technology techniques and behaviour change techniques

The results reported here indicate that: For a sample of PwCOPD with high levels of technology use, high levels of breathlessness and high physical activity levels; the virtual coach scenario was perceived as most persuasive overall, followed by the music and maps, then the online community scenario (though this scenario was the most divisive with the PwCOPD who were interviewed rating it as higher than the other two). When the individual techniques were rated those associated with dialogue support were perceived as most persuasive but there was no significant difference between these and those associated with primary task support. Primary task support features were used in all three scenarios, the popularity of the virtual coach scenario over the music and maps scenario could indicate that the addition of dialogue support to primary task support PTTs is perceived as most persuasive overall. The most popular feedback screen showed the goal with the amount of activity achieved as a bar graph. These findings should inform the future development of self-management technologies for this population.

The present findings suggest that using dialogue support techniques alongside primary task support techniques to support the self-regulation of physical activity in people with COPD are likely to be the most popular. There is also evidence that these PTTs are the most effective in predicting adherence to internet based health interventions (Kelders et al., 2012) and well as intention to use, and use of an internet based healthy eating intervention (Drozd et al., 2012). The use of social support techniques, while they may prove engaging for some, are less likely to appeal to the majority of users. This is especially true for any techniques that encourage any form of social comparison or competition; again these techniques are popular in apps that encourage increases in physical activity in the general public but not for those with COPD.

7.3.3 Limitations

As discussed in Section 7.3.1 the sample recruited for this study might not be generalisable to PwCOPD as a whole. All the participants recruited were a member of a support group, whether face-to-face or online and, as discussed above, this may have influenced their opinions of the online community scenario. They all agreed to participate in research related to technology and physical activity, which could indicate some level of interest in one or other of these areas. One of the advantages of including HCPs in the interviews was that they have a wide experience of people with COPD and could provide insights into this wider group. The HCPs' views and those expressed by PwCOPD who completed the survey broadly agreed, and this could indicate that the virtual coach scenario may appeal to a wider population of PwCOPD than the online community scenario.

The survey having a wider reach has advantages but also limitations. An accurate response rate might have helped to assess how representative the sample of PwCOPD who completed the survey were. Response rates can easily be calculated for a closed online survey (recruited by a link sent to an individual; Eysenbach & Wyatt, 2002). However judging how many people saw the invitation to the present survey is difficult. For the online completion it would have necessitated hit rates being calculated from visits to all the online support groups; this would have been difficult in itself, but also one of the acceptance emails from a moderator acknowledged that they had posted the link on other forums, and this may have occurred in other cases unbeknownst to the researcher. For the face to face support groups, due to the confidentiality of patient led groups, it was not possible to contact the groups directly. Therefore, how many groups distributed the invitations and how many members saw them cannot be known. This is of particular interest due to the low number of paper surveys returned, despite contacting over 140 Breathe Easy groups. The response rate was so low that it was not deemed time or cost effective to invite the remaining groups to take part. This could be due to a lack of interest in the topic, reticence to ring the researcher to request a survey, or fewer people seeing the invitation than originally thought. And finally, for the interviews when the researchers visited the Breathe Easy groups they left information sheets to post out to members who were not present at the meeting, however, the group moderators were not followed up in any way so it is unclear how many of these were sent out. For both the interviews and the surveys, better tracking of invitations, to ensure that members of the groups received them, would have enabled a response rate to be calculated. To address the low numbers of paper surveys returned, perhaps attending groups and handing out the surveys might have resulted in a higher number of respondents.

There were limitations with the design of the interview schedule and the survey. The interview schedule was semi-structured, and responsive to the participant's answers and opinions. This flexibility is advantageous in that it encourages participants to express their opinions and provides rich data, however without a strict schedule not all the features were spoken about in the interview. With the large numbers of features and techniques it would have been untenable to ask in detail about each, but this means there is a larger amount of qualitative data related to some features than others. For example *tips and advice for performing activity with COPD* was rated as the most popular feature by PwCOPD who completed the survey, yet it was not mentioned much in the interviews. This could indicate that the participants who were interviewed liked this feature less, but without specifically asking about it in the interview, this is hard to ascertain. In the survey, too few questions required answers, resulting in incomplete data sets being returned. In retrospect, all questions could have required a response provided that a 'prefer not to say' option is offered. This may have resulted in a larger number of dropouts, but it might also have stopped participants accidently missing questions.

The final limitation relates to the integration of the data. Although the interview schedule and the survey were designed to correspond, they did not collect identical data. In some cases participants who responded to the survey might have identified all three scenarios as highly persuasive, whereas the participants who were interviewed were encouraged to choose one, or a combination of two that they would use (or would recommend for use). Drozd et al., identified a link between perceived persuasiveness and intention to use a website, therefore, although these two could not be said to be measuring the same thing, it would still be expected that a scenario rated as least persuasive would also be associated with the lowest intention to use (2012). To explore this issue, additional information would be needed, such as whether the results would change if participants who completed the survey were encouraged to choose one or two scenarios they would use, as well as rating how persuasive they found the scenario.

7.4 Conclusions

The research reported in this chapter investigated the opinions and preferences of key stakeholders towards using persuasive technology to support and encourage increases in physical activity. Opinions of persuasive technology were on the whole positive; however opinions were dependent on personal preferences and initial levels of capability and motivation. The virtual coach scenario that used PTTs to support interactions between the user and the technology was the most popular, and techniques related to both dialogue support and primary task support were better supported than those related to social support. Future research should explore the relationships that have been hypothesised here to see how persuasive technology could be designed to engage and meet the needs of this population.

8 General Discussion

COPD is the 5th biggest cause of death in the UK, and the 2nd largest cause of emergency admissions (British Lung Foundation, 2007). Effective management of COPD relies on a combination of both HCPs who provide care, instruction, and advice; and PwCOPD who make changes to their lifestyles and behaviours to self-manage their condition (Bourbeau et al., 2004). The aim of this thesis was to explore the potential of persuasive technology to help PwCOPD make changes to their health behaviours and thus self-manage their condition more successfully.

The approach taken in this thesis was to combine techniques from both health psychology and persuasive technology, and explore intervention development using a range of methods. The work presented in previous chapters has synthesised the previous literature through systematic review and meta-analyses (Studies 1 and 2), assessed the acceptability and the capacity of a relatively simple persuasive technology to change behaviour (Study 3), and finally, explored the opinions and preferences of key stakeholders towards some novel persuasive technology techniques (Study 4). The individual findings, strengths and limitations of each of the studies has been presented in Chapters 2, 3, 5 and 7. This chapter will explore the findings of the project as a whole and how these add to the extant literature.

The findings are presented in three sections i) findings related to the evidence base that was drawn upon to design the persuasive technology (Section 8.1.1), ii) findings related to the acceptability of persuasive technology to PwCOPD (Section 8.1.2), and iii) findings related to the potential for persuasive technology to change physical activity in PwCOPD (Section 8.1.3). Following discussion of the key findings, the methodological aspects of this thesis (Section 8.2), and the strengths, limitations, and future directions of this area of research will be discussed (Section 8.3). Finally, a short reflective discussion that explores the potential influence of the researcher on the findings (Section 8.4) will be presented, and the conclusions (Section 8.5).

8.1 Key findings

8.1.1 Using the evidence base to explore behaviour change interventions for people with COPD

There are different approaches to developing interventions that target behaviour change. The Fogg 8-step design process for persuasive technologies (Fogg, 2009c), the persuasive systems design model (Oinas-Kukkonen & Harjumaa, 2009), the MRC guidelines for complex intervention development (Craig et al., 2008) and the behaviour change wheel approach (Michie, van Stralen, et al., 2011), all advise researchers to identify and build on the available evidence base. In this thesis, literature related to behaviour change interventions (BCIs) for PwCOPD that targeted either smoking cessation (Study 1), or physical activity outside of pulmonary rehabilitation (Study 2), were systematically reviewed. The novel contribution of this work was to use meta-analysis to calculate which BCTs were associated with effective interventions.

The review of smoking cessation interventions (Study 1, reported in Chapter 2) found that techniques that aimed to encourage self-regulation were more effective than those that aimed to motivate. This finding provides support for the two phase conceptualisation of behaviour change; a motivational phase that culminates in the formation of an intention to perform the target behaviour, and a volitional phase that culminates in the performance of this target behaviour (Gollwitzer, 1990). Willingness to enter a smoking cessation intervention might indicate a pre-existing motivation, or intention to quit, therefore techniques that target the volitional phase may be more effective for people who are already willing to quit. However, motivational techniques should be used to target those individuals with COPD who do not currently intend to quit (Hilberink, Jacobs, Schlösser, Grol, & de Vries, 2006).

The quit rate for PwCOPD reported in Study 1 (approximately 13%) was lower than the target for the Stop Smoking Services (35%), however, due to the high cost of continued treatment for PwCOPD, even interventions with a low quit rate could still represent cost effective treatment (West, 2007). To put this finding in context, in 2010 Hoogendoorn and colleagues found that, taking into account the costs of delivering intensive counselling and pharmacotherapy, a quit rate of 12% would result in a cost of £1950 per quality adjusted life year (QALY) over a 25 year period (Hoogendoorn et al., 2010). NICE currently consider treatments costing <£20,000 per QALY to be cost effective (National Institute of Health and Care Excellence, 2010b). Future research in this area could further explore the BCTs identified in Study 1, to tailor smoking cessation services for the COPD population. Any interventions that lead to increases in the quit rate for this population are likely to be both beneficial to PwCOPD and cost-effective.

Study 2 (reported in Chapter 3) systematically reviewed interventions that targeted physical activity outside of formal PR programs, another key behaviour for PwCOPD. The positive effects gained through a course of PR can only be maintained if the person with COPD continues to be active in their daily life (Bourbeau, 2009b). Recent evidence suggests that completion of a course of PR does not necessarily confer these changes in levels of activity (Egan et al., 2012). Low levels of physical activity for those with COPD have been associated with increased risk of hospital admissions (Garcia-Aymerich, Lange, Benet, Schnohr, & Anto, 2006) and 48 month mortality (Waschki et al., 2011).

Study 3 focused on interventions that contained fewer than two supervised sessions per week, together with sessions that were undertaken independently by PwCOPD. This was to avoid reviewing programmes that were similar in intensity to PR, and instead identify those that encouraged PwCOPD to participate in activity unsupervised. Overall the interventions synthesised had a medium-sized effect on physical activity according to Cohen's classification of effect sizes (Cohen, 1988). This is a promising finding as the interventions considered in Study 3 had a lower number of supervised sessions per week than the minimum recommended for PR, yet their effectiveness was comparable (Lacasse et al., 2002; Salman et al., 2003). The review further identified that the provision of COPD specific information, in addition to components related to physical activity, was associated with more effective interventions. However, the findings should be interpreted with caution due to the small samples used by some of the studies, and the possibility of publication bias.

While this limitation means that the findings need cautious interpretation, it also serves to highlight the quality of the available studies that assess self-managed physical activity as part of an intervention. The small sample sizes used meant that many of the analyses reported in the included studies were under-powered. Furthermore, many did not report important information related to adherence to the unsupervised activity sessions. These limitations make it difficult to ascertain a more precise estimate of the effect of physical activity interventions on behaviour, and are surprising given the recognised importance of physical activity to the self-management of COPD. The small numbers of studies available in this area has been noted by Ng and colleagues, who aimed to ascertain the effect of supervised exercise training on general physical activity behaviour, but were unable to identify a single randomised controlled trial in the area[15] (Ng, Mackney, Jenkins, & Hill, 2012). Reporting the results from under-powered analysis is a wider problem that affects areas outside of physical activity in COPD. In 2010 a review of medical publications was undertaken to identify how pilot studies and feasibility studies were being reported. The authors found that there was an 'inappropriate emphasis on hypothesis testing' in many pilot trials (Arain et al., 2010, p.1). Publication bias may then amplify this influence as small trials are more likely to be published if the results show statistical significance. To reduce the influence of publication bias on review findings, the NHS Health Research Authority has recently (as of 30th September 2013) made it a requirement that all clinical trials are registered on a publicly accessible database as a condition for NHS ethical approval (NHS Health Research Authority, 2013). This change should allow researchers conducting reviews in the future to identify relevant studies described in clinical trials databases, but that have not been published. There have been recent calls to improve the descriptions of interventions in published papers, or online appendices (Hagger, 2009; Hoffman, et al., 2014; Lippke & Zielgelmann, 2008; Michie, et al., 2009; Michie & Prestwich, 2010; Michie, van Stralen, et al., 2011; Schaalma & Kok, 2009); the template for intervention description and replication (TiDiER) guidelines specifically advise reporting details of adherence to the intervention (Hoffman et al., 2014). If these guidelines are followed adherence to both supervised and unsupervised physical activity sessions could be included as a moderator in future meta-analyses.

The systematic reviews described in Chapters 2 and 3 aimed to identify the evidence base on which a new intervention could be built and explore previous interventions that have been effective (or ineffective) for PwCOPD. The target behaviours smoking and physical activity were chosen for the reviews as it was thought that these are likely to apply to the widest range of PwCOPD, and they had behaviour change outcomes that were measurable in a short amount of time, with a small sample (which was needed for the empirical work). Following these reviews it was decided to focus on physical activity as a target behaviour. It was thought that there was greater need for research in this area due to the NHS SSS already utilising elements of persuasive technology, and the small numbers of studies available looking at activity levels of PwCOPD. This course of action was supported further by speaking to HCPs in the locality of the research and by the compatible ongoing research in the department.

Participants were thought to be motivated to engage in physical activity initially, so BCTs aimed at the volitional stage of behaviour were used. These BCTs, aimed at self-regulation, included goal-setting and self-monitoring. They were thought to be well suited as there was

[15] The inclusion criteria for this review specified that physical activity had to be measured objectively with activity monitors

evidence supporting their use to increase physical activity (Michie, Abraham, et al., 2009), they are already widely used in persuasive technology applications for the general public, and elements of this approach had already been implemented by researchers in the department for people with heart failure. In the original version of the behaviour change taxonomy (Abraham & Michie, 2008), the techniques chosen in this thesis were associated with the control theory approach to self-regulation (Carver & Scheier, 1982). While this has proven a useful framework by which to explain the results, it should be noted this is not the only theory associated with these techniques. The technique *specific goal-setting* for example features in the action planning component of the Health Action Process Approach (Schwarzer, Lippke, & Luszczynska, 2011), as well as goal-setting theory (Locke & Latham, 2002).

8.1.2 Acceptability and acceptance of persuasive technology by PwCOPD and key stakeholders

The feedback from PwCOPD and other key stakeholders on using persuasive technology to increase physical activity was largely positive. Although there were suggested changes and improvements, very few participants rejected the use of technology for this purpose outright. This statement is evidenced by the findings of Studies 3 and 4 (reported in Chapters 5 and 7). In Study 3, six out of seven of the participants reported that the mobile phone application was easy to use, and five participants said that they would continue to use the technology outside a research study. Furthermore, in Study 5, all the interviewed participants were able to choose either one, or a combination of more than one, of the scenarios that they would like to use, or would use with PwCOPD; and the survey results showed that the perceived persuasiveness of each of the scenarios was relatively high (Chapter 7). This is not to say that persuasive technology for increasing activity was universally supported, but the majority of the opinions expressed were positive.

Negative comments were made in response to the survey reported in Chapter 7, and even those who found the idea of persuasive technology acceptable themselves expressed uncertainty when they considered wider adoption by others. The ability to be physically active, interest in increasing activity, previous experience of technology, and interest in using technology, were all identified as factors that may affect initial opinion of persuasive technology (see Figure 7.16 in Chapter 7). The concerns expressed by participants about acceptance of the technology by others with COPD echo those expressed in the eight-step process involved in the design persuasive technology. Step 2 involves choosing ‘a receptive audience’, which is defined as an audience that already has an intention to change the target behaviour, and already use the technology channel that is chosen by the designers (Fogg, 2009c).

An interest in technology and previous experience of using technology were deemed by participants to be likely to influence initial acceptance of the persuasive technology. In the context of the Unified Theory of Acceptance and Use of Technology (UTAUT) theory (Venkatesh et al., 2003); both previous experience[16] of technology and interest in technology could be thought to influence the amount of effort that people perceive the technology to require (effort expectancy), or their beliefs about whether the technology will have positive effects on physical activity (performance expectancy). Alternatively, both interest in, and previous experience of, technology could be seen as indicative of *innovativeness*, which describes how willing a person is generally to try new technologies (Rogers, 2003). Innovativeness has previously been found to significantly affect how easy people perceive telecare products are to use (Huang, 2013). Choosing a receptive audience in terms of their initial interest in technology and their interest in changing their levels of physical activity is supported by the results reported here. However the findings reported in Chapter 6 indicate that previous *use* of hardware was not necessary, and therefore should not be used to select an appropriate technology channel as suggested by Fogg (2009c).

Those participants who had not used a smartphone previously, reported that they could and would use this novel technology. Therefore instead of relying on previous use of the technology, it could be suggested that the user, technology, and proposed use of the technology should be considered as a whole to ensure a good *fit* (Zayas-Cabán & Dixon, 2010). This approach is already taken in the area of assistive technology, which routinely matches individuals with technology that is likely to be new to them (e.g. Scherer & Craddock, 2002). It is therefore recommended, based on the findings of Studies 3 and 4, that intervention designers choose the most appropriate technology channel (both hardware and software) for the user and the context of use, and do not limit themselves to technology that is likely to be familiar to the target users. This may be especially relevant when considering an older adult population who may be less familiar with recent advances in technology (Waycott et al., 2012). While it is the case that any intervention that relies on a specific technology channel risks obsolescence in the future (Schueller, Munoz, & Mohr, 2013), technologies that limit the channel used to one that an older adult population would be likely to be familiar with may accelerate this process. Furthermore, technology is constantly evolving, with new technologies potentially capable of influencing behaviour in new ways. Limiting the choice of channel would mean that intervention designers might not be able to use this new potential (Riley et al., 2011).

[16] NB: This is previous experience of technology in general and not to be confused with the construct 'Experience' within the UTAUT which refers to the level of experience a person has with the specific technology being evaluated.

As outlined in Chapter 1, previous research has identified the importance of tailoring in encouraging both engagement with technology, and behaviour change. However, models either provide a wide range of possible targets (Oinas-Kukkonen & Harjumaa, 2009), or are non-specific about *how* the technology should be tailored (Wiafe, Nakata, Moran, & Giulliver, 2011). The findings of Study 4 help to address these limitations and identify how technology could be tailored for PwCOPD. Two approaches were found: i) to tailor the *goals set* using characteristics of the user and ii) to tailor the *role* that the technology should play using the situation that the user is in, and the support that they already have available. As outlined above, participants identified certain personal characteristics that may influence their acceptance of technology to promote physical activity. If the goals set were not deemed appropriate to the user in terms of these factors (e.g. physical activity capability or interests), then the technology would not be used. Therefore, the first approach to tailoring is to ensure the goals set are deemed appropriate by users (goal-setting will be further discussed below in Section 8.1.3). The second approach to tailoring is informed by participants in both Studies 3 and 4, who felt that persuasive technology would be most useful if it satisfied an unmet need in the user. For example, if the user is motivated but lacks social support, a persuasive technology that facilitates social support might be the most helpful. Alternatively, if the user has social support but needs a trigger to begin their physical activity, a persuasive technology that uses reminders and suggestions might be more effective. To identify which aspects might be missing for an individual, the COM-B model and Fogg Behaviour Model could be used (Fogg, 2009a; Michie, van Stralen, et al., 2011). Between them these models identify four necessary conditions for behaviour to change; motivation, capability/ability, opportunity and a trigger (Fogg, 2009a; Michie, van Stralen, et al., 2011). Persuasive technology could then be tailored to address whichever aspect is needed by an individual.

The contribution that the present research makes to the literature on technology acceptance is the finding that persuasive technology to increase physical activity is perceived largely positively by PwCOPD; as well as the identification of specific approaches that can be used to tailor such technology which might boost acceptance. Wider inferences can also be made relating to the nature of technology acceptance for this population. The authors of the UTAUT (Venkatesh et al., 2003) describe acceptance as when a user forms an intention to use the technology, then uses the technology; with the inference that use implies acceptance. The alternative is for the user to reject the technology by not forming an intention to use it, and then not using it. The findings from Study 4 suggest that key stakeholders view persuasive technology in the same way. It was felt that if people fulfilled the criteria identified for initial interest in the persuasive technology (i.e. ability to be physically active, interest in increasing activity, previous experience of technology, and interest in using technology) and were provided with an appropriately tailored technology, then they would accept, and use this technology. Alternatively, those who did not fulfil the initial criteria, or for whom the technology was not appropriately tailored would reject the technology, and not use it. However, the results of Study 3 showed that, although using persuasive technology to increase activity was found to be acceptable and the technology was used for the month that the participants had it, the majority of participants did not use the technology to increase their physical activity. This could indicate that participants did not fully accept the technology, and that changes would need to be made to the behaviour change elements within the technology to promote acceptance and encourage effective use (discussed in Section 8.1.3). The findings reported in Study 3, therefore, do not support the hypothesis that use implies acceptance, and non-use implies rejection. Instead they corroborate the finding that older adults are more likely than younger adults to use a technology without fully accepting it, and that acceptance should, therefore, be represented as a continuum that does not have to result in full acceptance or rejection of the technology (Gelderblom et al., 2010).

The authors of the Senior Technology Acceptance and Adoption Model (STAM; Renaud & van Biljon, 2008) suggest that older adults pass through three stages when accepting a new technology; i) *objectification*, ii) *incorporation*, and iii) either *conversion* or *non-conversion*. Actual use of the technology and experimenting with it occurs during incorporation, then depending on how easy the technology is to learn and use, it may be accepted or rejected. The STAM puts a greater emphasis on what happens after the technology is first used and identifies some of the factors that might influence whether it is accepted or rejected, though the model still does not allow for a partial acceptance, unless older adults remain in the incorporation phase indefinitely. Recent evidence related to older adults' acceptance of smartphone features has suggested that acceptance of a product might be separate from acceptance of specific functions (Zhou, Rau, & Salvendy, 2013). This supports the findings of the present research where the phone and the self-monitoring feature seemed to be accepted, whereas the functionality that allowed PwCOPD to set their own goals was not. As technology advances, becomes more flexible, and is able to be tailored for individuals, the factors that influence acceptance may change (for both younger and older adults). The greater understanding researchers and developers have about these factors, the more acceptable their designs are likely to be (Zhou, Rau, & Salvendy, 2012).

It has been suggested that three 'types' of change can occur following use of persuasive systems i) compliance ii) behaviour change or iii) attitude change (Oinas-Kukkonen, 2013). Rather than use, it could be more helpful to consider 'effective use' of technologies (Zayas-

Cabán & Dixon, 2010) to ensure that behaviour change occurs (rather than just compliance with the system). To begin this process, an individual would need to believe a technology was both acceptable and able to change behaviour; otherwise even compliance with the system would be unlikely. One of the key tenets of persuasive technology is that it has to be persuasive, not coercive, and this implies choice (Fogg, 2003). The findings reported in this thesis identify the factors that are thought to influence whether PwCOPD will find persuasive technology acceptable. Only once the technology is perceived as acceptable will people choose to use it, and only when people begin to use it, can the other strategies suggested here, such as tailoring, be used to increase acceptance and perhaps move towards behaviour change.

8.1.3 Persuasive technology in the promotion of behaviour change for PwCOPD

The persuasive technology investigated in Studies 3 and 4 was based on combinations of BCTs and persuasive technology techniques. As outlined in Section 8.1.1, the BCTs (goal-setting, self-monitoring, feedback, and review of behaviour goals) were classified as associated with control theory (Carver & Scheier, 1982) in the 2008 behaviour change technique taxonomy (Abraham & Michie, 2008). Self-monitoring, goal-setting, and receiving feedback on performance are also commonly used in mobile phone apps available for the general public to increase activity (see Chapter 6 and Conroy et al., 2014 and Kirwan, Duncan, & Vandelanotte, 2013) although there is relatively little evidence of efficacy of mobile BCIs (Free et al., 2013). Study 3 explored participants' everyday experience of using persuasive technology for a month, and their opinions of the techniques were informed by this experience. These findings were then compared with an objective measure of behaviour change. Study 4 explored a wider range of persuasive technologies, both in terms of the techniques used, and how these techniques could be put into operation. The findings presented in this general discussion, therefore, are drawn from participants' direct experience, objective changes in behaviour, and the opinions of key stakeholders towards prototype systems.

The findings related to feedback were largely similar in Studies 3 and 4. Simple, clear, meaningful feedback, and the presence of a comparison between actual and desired activity level were all reported as key components of a feedback display in both studies. As discussed in Chapter 5, being aware of the discrepancy between performance level and goal is necessary to make changes to both behaviour and the goal. Receiving feedback that current performance is below the current goal (also known as negative goal performance discrepancy) is thought to motivate changes in behaviour to increase performance to meet the goal (Carver & Scheier, 1982; Moskowitz, 2012), especially among those with higher self-efficacy (Bandura & Cervone, 1983). For those with low self-efficacy, failure to reach the goal may result in the goal being perceived as unachievable, and this reduces the effort put into striving to meet the goal

(Playford et al., 2009). In this situation, to address the negative goal performance discrepancy, individuals can either revise the goal downwards, or disengage from an unachievable goal, and set an alternative goal. Research has shown that for older adults (compared to college students) in this situation, re-engagement with an alternative goal is key to maintaining well-being (Wrosch, Scheier, Miller, Schulz, & Carver, 2003). PwCOPD may have to disengage from certain goals as they adjust to their illness, or as a consequence of a permanent worsening of symptoms, however in some cases a goal that is unachievable one day due to an exacerbation or external factors such as the weather, may be achievable again in the future. How an individual reacts to not achieving a goal may influence what actions are taken. As outlined in Chapter 7, frustration may lead to increased effort, whereas sadness is more likely to lead to goal disengagement (Mann et al., 2013). This may explain why a feedback display that indicated performance was below the goal was perceived differently by different participants (see Chapter 7). One person with COPD said that seeing how badly they had done would motivate them to do more, whereas the HCPs were wary it would be seen as overly negative. How to feed back information when PwCOPD do not reach their goals, without negatively influencing their emotions, and consequently future goal striving activity, is therefore important.

In Study 3 the technology used stopped recording activity once the goal was reached. Participants suggested that it would have been an advantage to show performance that exceeded the goal (positive goal performance discrepancy), in the feedback display, when this was achieved. Previous research has shown that, if an individual receives feedback that they have met or exceeded their goal, they are more likely to set an increased goal for themselves (Bandura & Cervone, 1983; Donovan & Haufsteinsson 2006; Williams, Donovan, & Dodge, 2000). Participants in Study 3 believed that seeing a positive discrepancy between desired and actual performance would increase the likelihood of them increasing their goals. However, for the majority of participants, feedback showing that the daily goal had been met did not encourage them to increase their goals, with most participants preferring to keep the same goals (see Chapter 5).

To explore the reasons behind this reticence to increase goals, it is necessary to consider several factors related to both initial goal setting and the ongoing review of goals. The interview data reported in Chapter 7 identified that the goal must be seen as appropriate by the user, both in terms of the activity suggested and its duration and/or intensity. As mentioned above, the perception that the goal is achievable promotes goal striving (Playford et al., 2009) and either low-self-efficacy (Bandura & Cervone, 1983), or a goal that is genuinely beyond the individual’s capacity, is likely to negatively affect how achievable the goal is thought to be. However, according to goal-setting theory, goals that are more challenging are associated with spending more time goal striving (Locke & Latham, 2002). The initial goal, therefore, should be seen as challenging but achievable and appropriate to the individual users. As seen in Study 3, some users will set their own goals when the opportunity is presented, whereas others will not.

Persuasive technology could provide a stepped approach to goal-setting in the future, beginning as a way of supporting communication between the HCPs setting goals, and PwCOPD striving to meet them. Over time, as PwCOPD gain in confidence, they could begin to set their own goals, while still monitored by the HCP. The final stage could then be complete self-management, assisted only by the technology. Using persuasive technology in this way would embed technology aimed at behaviour change more into the healthcare service and persuasive technology could become an adjunct to a more traditional self-management intervention. In the latest update of a Cochrane review in this area, the authors aimed to separate self-management programmes from those that focus solely on education. The authors defined self-management programmes for PwCOPD as requiring: 'At least an iterative process of interaction between participant and healthcare provider, and ideally also [the] formulation of goals and provision of feedback' (Zwerink, et al., 2014, p. 7). As an example of how persuasive technology might be used to achieve this, Verwey and colleagues have developed a smartphone app that allows self-monitoring and provides feedback, which is delivered to PwCOPD as part of a counselling intervention based on the 5 A's (Assess, Advise, Agree, Assist, Arrange; Verwey et al., 2012). PwCOPD meet with the counsellor three times to talk about their motivation and receive help with setting SMART (Specific, Measurable, Achievable, Realistic, Time-bound) goals for increasing their activity. A pilot study assessed the feasibility of this approach in a primary care setting in the Netherlands, and reported positive results (albeit with some technical difficulties; Verwey, Van der Weegan, et al., 2014). To assess whether the persuasive technology element adds value over and above the counselling intervention a three arm RCT is currently underway (Verwey, van der Weegen, et al., 2014). The results reported in Chapter 7 indicate that PwCOPD may accept the technology taking on the role of a 'virtual coach', and this would enable persuasive technology to take a more active role which might support either the phasing out of HCP support, or allow for a lower level of HCP involvement. Further research in this area could explore the optimum balance of HCP and persuasive technology to support behaviour change.

As an over-ambitious goal was seen as detrimental to motivation and also potentially dangerous if it resulted in striving beyond physical capability, in Study 3 the initial goal was set conservatively. Participants could choose an initial walking duration, and the researcher also had a duration that had been identified by the physiotherapist as safe for each participant. The lower of these two values was chosen as the initial goal. To encourage participants to increment their goals once achieved, the persuasive technology incremented the goal by 1 minute if each walk was rated as 'just right' for seven days. However, neither the initial goal setting nor the encouragement to review the goal challenged the participants, so the goals set could be achieved relatively easily in most cases, even with the increment. In not setting more difficult goals for themselves, the participants in Chapter 5 could have been motivated by avoiding failure, rather than motivated by achievement (Gollwitzer, Kappes, & Oettingen, 2012). Anticipating a negative emotion as a result of goal striving (for example, sadness, or embarrassment at not reaching the goal) has been found to negatively influence volitional activities (action that helps to translate a goal into action, such as forming implementation intentions), and therefore can make action towards the goal less likely, and subsequently goal achievement less likely (Bagozzi & Pieters, 1998). If the thought of revising the goal upwards was associated with an anticipated negative emotion (e.g. fear of failing) this may explain why a number of participants in Study 3 were satisfied as long as they could avoid this. How apps can present feedback information without adversely affecting the user's mood has been identified as one of the key future challenges in behaviour change app development (Dennison et al., 2013). An alternative explanation could relate to the cognitive effort that self-regulation involves. In a recent meta-analysis (French, Olander, Chisholm, & McSharry, 2014), it has been suggested that, due to this cognitive effort and a lower level of executive functioning than younger adults, older adults may have less ability to self-regulate their behaviour. This could result in BCIs based on self-regulation BCTs being less effective in this population. As outlined in Chapter 1, the Fogg Behaviour Model identifies a trigger as a necessary pre-cursor to behaviour change (Fogg, 2009a). Research has shown that implementation intentions can reduce the mental effort of carrying out goals, as goal actions are linked to specific opportunities to act (Gollwitzer & Sheeran, 2006). Participants in Study 4 were positive about the potential for reminders to be a useful addition to the virtual coach system. This could indicate that techniques to reduce the cognitive load of self-regulation might be useful and acceptable for this population. Future research could investigate the addition of reminders and implementation intentions to reduce the cognitive effort required to self-regulate behaviour.

As outlined above, the techniques based on psychological theory (i.e. goal-setting, self-monitoring, review of goals and receiving feedback) were relatively well-received by key stakeholders, and the delivery of these techniques through technology was also supported, albeit with improvements suggested that could increase the potential for persuasive technology to change behaviour. In contrast, however, some of the more novel persuasive technology techniques that often appear in apps available for the general public were not well received within this population. Additions such as incentives, in the form of stars/trophies or monetary rewards, were not seen as helpful. The impression was that these types of rewards are not what PwCOPD would do the activity for; instead they would do it to feel better (see Chapter 7). Two recent systematic reviews of the effects on older adults' health of using physical activity games (such as those on the Wii-Fit; Bleakley et al., 2013; Hall, Chavarria, Maneeratana, Chaney, & Bernhardt, 2012) reported that there is some evidence of positive effects on both cognitive and physical health, although the trials included were small. There is currently a lot of interest in the literature about including features in health care technology that mimic computer games. This can be referred to as 'gamification'. A recent editorial in the *Journal of the Royal Society of Medicine* outlined the potential future impact of gamification in health (King, Greaves, Exeter, & Darzi, 2013). The idea is that by assigning points, providing badges or rewards, and encouraging social competition, some of the fun and motivating aspects of playing computer games could be used to promote health-related behaviour and outcomes. While research interest in this area is growing, and the apps available for the general public indicate that this approach is well received (at least in terms of attracting downloads), recent findings have indicated that there may be some concerns when applying this to a population with chronic illness. Specifically, there are concerns that playing the game could reduce intrinsic motivation and replace it with extrinsic motivation (McCallum, 2012), which has been found to be associated with poorer self-regulation (Ryan & Deci, 2000). In a paper that aimed to present the state of the art of gamification in 2012, Groh compares providing extrinsic motivation through the use of a game to the social psychology concept of 'over-justification'[17] (Groh, 2012). The findings reported in this thesis show that participants felt their intrinsic motivation was a key factor in promoting behaviour change, and that extrinsic motivation such as incentives would not make a difference.

The importance of intrinsic motivation was explicitly referred to by participants, when the online community scenario was discussed. Some participants, explained they were negative about this scenario, as people who engaged in competition might miss the point of increasing their physical exercise, which was to feel better. A further concern, related to introducing competition, was raised by the HCPs and PwCOPD interviewed in Study 4. Concern was expressed that some individuals may deliberately set low goals in order to achieve points and win competitions, when those setting challenging goals but not achieving them would go

[17] 'Over-justification' was used to explain the phenomenon that children who were offered a monetary reward to draw pictures, drew a greater number but enjoyed drawing them less than children who were not offered any incentive (Lepper, Greene, & Nisbett, 1973).

unrewarded. This concern was also raised by McCallum (2012), and termed 'meta-gaming'; individuals finding ways to 'trick' the game, with the purpose of winning (or accruing points) without increasing activity. These findings suggest that, whatever mechanics are employed by the persuasive technology, the 'point' should always be to foster intrinsic motivation to increase activity, and only this increase in activity should be rewarded.

In a recent qualitative study (Karppinen et al., 2014) participants were interviewed about using a web site to aid weight loss. As part of the interview, participants were asked if they saw the website as utilitarian or hedonic (enjoyable for its own sake). Contrary to the authors' expectations, participants valued the utilitarian aspects of the web site and expressed wariness of introducing any aspects targeting fun or enjoyment as *'losing weight is a serious business'* p. 3049. The 'seriousness' of the intended behaviour change, and the consequences for either achieving or not achieving this change, could identify a key difference between applications aimed at self-management of chronic illness and those that are available for the general public. This may explain why the gamification aspects included in the scenarios were less popular amongst this population with COPD than they seem to be among the general population.

8.2 Methodological discussion

Three main methods have been used in this thesis; synthesis of previous literature (Studies 1 and 2), a series of *N*-of-1 studies testing a persuasive technology (Study 3), and interviews and surveys that gathered user opinion (used in both Studies 3 and 4). These approaches were deemed necessary as, without consulting the existing evidence base, intervention approaches that either have no evidence, or have evidence contradicting their use, could have been chosen. Without the *N*-of-1 studies, technology that does not have the desired effect on behaviour could have been designed. Finally, without gathering user opinion, technology could have been designed that no one would use. As this research informs the preliminary stages of intervention design, each of these sources have increased understanding of this area and can inform future iterations of this technology. However, the amount of data produced can be problematic. In Study 4 at least one participant chose each of the scenarios as the one that they would use, and participants were positive about a wide range of the features that were suggested in the scenarios. To develop a system that incorporated all of the elements presented would not only be prohibitively expensive and time consuming to program, it would also potentially sacrifice the simplicity of the system, which participants also identified as important. To guide the decision about which sources of information to use, and what to do if they contradict each other, the role that the participants play in the research should be considered in each case.

In their work on patient and public involvement, Forbat and colleagues describe a number of different roles that individuals can take in research studies; acting individualistically, as consumers of healthcare; as citizens acting socio-democratically, for the good of their group; as partners in research, providing experiential knowledge; and as co-researchers, having an active impact on the direction and process of the research (Forbat, Calyless, Knighting, Cornwell, & Kearney, 2009). In the current research, participants in Study 3 provided information related to behaviour change, but in addition they were asked for their opinions and made aware that the research was at a developmental stage. This means that, rather than being passive recipients of the intervention, participants may have considered themselves as partners in research, influencing the future direction of the research, or representatives of PwCOPD as a whole. This latter role was clearly present in Study 4; participants would often answer using generic terms and talk about 'people' rather than answer directly for themselves. It is important for researchers to be aware of the different roles that participants may take and how this may influence the data collected. If these role expectations do not match between the researcher and the participant, the answers given may unintentionally mislead the researcher. For example, if asking if a piece of technology would be acceptable, a participant may answer 'yes' meaning that it would be acceptable to them personally (individualistically) or 'yes' it seems like it would be acceptable to PwCOPD (socio-democratically). To prevent reporting misleading results, researchers should aim to be clear about the role they expect the participant to take, and check information throughout the interview by using probes. In the above situation a researcher could ask 'Would *you* use this technology?' or 'How would you use this technology in your life?' to clarify whether the participant is answering from themselves or the group.

Each of the stakeholders involved in the design of a piece of persuasive technology (e.g. potential users, software developers, health services researchers, health care professionals) have unique perspectives, and each should play a role in the design (Becker et al., 2014). There have been recent calls to combine the expertise of software designers and behaviour change researchers to create behaviour change technologies (e.g. Becker et al., 2014; Cowan et al., 2012; Schueller et al., 2013). Based on the experience of carrying out the research for this thesis, a possible framework for this combination, in the context of a healthcare setting, is suggested in Figure 8.1. As outlined in Chapter 6, designers of apps may have very little insight into how an intervention would work with older adults' lifestyles, and within a care pathway. Similarly, in the case of the present research, PwCOPD may have little understanding of the potential features that a piece of persuasive technology could have. Information related to needs, healthcare setting, clinical guidelines, theory, previous empirical work, and experiential knowledge may all be important to feed into the design of a BCI. However, if all of the stakeholders comment on all aspects of the intervention, the large amount of data generated can be hard to utilise effectively. When planning a project, therefore, researchers could think about what area each stakeholder's knowledge is likely to be most useful in, and then ensure that priority is given to this source at the appropriate point in the project. In the design stage, the target of the BCI might be identified by enquiry into desired behaviour change outcomes, and potential barriers from the end users. Approaches to this might be drawn from PwCOPD and HCPs', experiential knowledge or current guidelines and care pathways. The behaviour change researcher might then use their knowledge of theory and previous research to identify BCTs to address the target behaviour, and overcome the barriers, in combination with the above information. In the programming phase of the project, specialists in computer programming and user experience (UX) might be involved to provide input related to the technological architecture, components that might promote engagement with the technology, and improving usability. Usability would then need to be assessed by the end users, in terms of whether they were able to operate the technology, and also that it fit within their lifestyle (PwCOPD) or work patterns (HCPs). The behaviour change researcher and the HCPs may also provide information about the components that might promote change and engagement. By involving a range of key stakeholders, and making the best use of their involvement, it is hoped that the resultant behaviour change technology would be acceptable to the end users, promote effective use from PwCOPD, efficient implementation for the HCPs, and result in the desired behaviour change and consequent positive effects on health outcomes.

Although described as a linear process above, designing persuasive technology is an iterative process and it involves not only bringing together different people (as described above) but also bringing together different research cultures. As outlined in Chapter 1, designers of persuasive technology advocate rapid iterations of the testing and design cycles to ensure that resources are not wasted producing something that does not have the intended effect on behaviour (Fogg, 2009c). Designers of BCIs (especially those who target people with chronic illnesses) need to go through ethical approval procedures to conduct research. While these approvals are necessary to protect potential participants, the time taken to obtain them represents a barrier to testing innovative technologies in health settings (McCallum, 2012). In this thesis, a series of *N*-of-1 case studies were used to provide initial evidence of behaviour change. This methodology enabled both behaviour change and the reasons behind it to be explored in depth, with relatively few participants. This methodology meant that the research could be undertaken relatively quickly, and the findings can now inform the next iteration of the technology.

8.3 **Strengths, limitations, and future directions**

The main strength of this thesis is the range of methods used to provide evidence on technology-based strategies for promoting behaviour change amongst PwCOPD. The combination of systematic reviews with meta-analyses, detailed research with PwCOPD, and surveys of a wider sample, allowed preliminary evidence related to both the acceptability of interventions and actual behaviour change to be reported. Encouraging self-management behaviours in PwCOPD is complex and using this multi-faceted approach to data collection and analysis can provide a deeper understanding of the phenomenon and inform future iterations of persuasive technology. In the time since this project began (in 2011) the number of apps available at popular app stores related to COPD has grown from 4 to around 120 (in 2014)[18]. There is still, however, relatively little evidence of the efficacy of mobile health interventions aimed at either behaviour change, or disease management (this includes both apps and text message-based interventions; Free et al., 2013). In a recent systematic review of clinical trials of smartphone applications for chronic disease management (Wang et al., 2014), only one app was related to COPD; this trial assessed an early internet enabled mobile phone that played music at a tempo that would encourage PwCOPD to walk at a certain speed during exercise training (Liu et al., 2008). While this was found to be effective, the apps that are currently available are a lot more complex, and more information about their efficacy is needed. Various attempts are being made to regulate and certify apps, by the NHS, the Food and Drug Association and others and evidence of efficacy would be useful to inform this process. Discussions around the logistics of certification, and what kind of evidence should be used to support it, are likely to remain important in future years (Becker et al., 2014).

In addition to the advances in mobile apps, there is growing recognition that, while PR is essential, the level of physical activity undertaken by individuals outside of PR is also important. A recent meta-analysis suggests that PR only has a small effect on activity outside of the supervised classes, and that there are currently too few studies that assess physical activity (Ng et al., 2012). Ng et al's review looked at activity levels while supervised sessions were being attended, and previous research has already found that the improvements gained in fitness are often lost when these sessions end, indicating that activity levels are not maintained following the supervised classes (Egan et al., 2012). Therefore, the time seems right to investigate interventions that can provide support to PwCOPD to increase daily physical activity outside PR and encourage self-management. Finally, there have been advances in the approaches taken to design health behaviour interventions, with the

[18] NB: Both these counts include apps that target health professionals working with PwCOPD as well as PwCOPD

introduction of a 93 item taxonomy of behaviour change (Michie et al., 2013), and the publication of the behaviour change wheel approach that allows intervention designers to draw links between the behaviour, the barriers, the techniques, and the intervention functions that should be used (Michie, Atkins, & West, 2014). A further strength of the present research therefore, is that the findings can be incorporated into the growing body of evidence in this area, and still contribute a novel approach to the problem addressed.

One of the limitations of the present research is that, although the evidence base was systematically reviewed, there were only small numbers of papers available, those that were often had small sample sizes, and in some cases the interventions were not adequately described. Ideally insights would be drawn from a larger number of studies, studies with larger samples, and that describe the interventions used in greater detail. The technique of mathematically synthesising previous trials is most robust when the trials involved are high quality and well described, to minimise the potential for variance from unmeasured sources. However, there is a balance to be gained in including studies that have high internal validity, and studies that are likely to represent the population of interest (high external validity). It is accepted that there are inherent limitations in using meta-analysis to integrate effect sizes across different behavioural interventions (these are outlined in Section 2.4). As a minimum, reviews of this kind should note this limitation, but the alternative is for designers of BCIs not to use techniques such as meta-analyses and accept that there cannot be a quantifiable consensus on what might be effective at changing behaviours. This would leave developers to design BCIs idiosyncratically, and without guidance from previous research. The advances made in this area, e.g., more precise intervention descriptions (Hoffman et al., 2014; Michie et al., 2013), and methodologies that aim to look at the relationships between techniques (Dusseldorp et al., 2013), should both help to make the mathematical synthesis of behavioural evidence more robust, and future work should utilise these where possible.

A second limitation of this project is that the sample may not be representative of PwCOPD as a whole in terms of attitude towards both technology and physical activity. Throughout the research studies effort was made to be as inclusive as possible of people with any level of technology experience. The interviews were open to all, all the technology necessary for the *N*-of-1 studies was provided by the researcher, and the questionnaire was available both online and on paper. However, as part of the informed consent process, participants were told that the studies were about technology and physical activity. Therefore, participants who consented were probably more interested in technology than the general population of PwCOPD. While this is a limitation, and caution should be taken generalising the findings to all PwCOPD; this type of intervention will always be optional, and the people who are most likely to take it up are those who are more interested in technology. It is also the case that these are preliminary findings that will inform future cycles of development and testing. By the time this technology is ready for implementation, the number of PwCOPD to whom these findings apply is likely to have grown as smart phone adoption increases (Ofcom, 2013), and current smart phone users age. However, it is likely to always be the case that there are some people for whom a technology based intervention will never be acceptable.

The second sample limitation related to participants' motivation to be physically active. The persuasive technology was designed to support the volitional phase of behaviour change. It was therefore deemed important to recruit people who were already motivated and intended to increase their activity. The participants recruited in Study 3 were motivated individuals; they had completed the PR course, were attending maintenance classes, and were aware of the positive effects of physical activity on their health. However, some participants were already doing relatively high levels of physical activity at home, and therefore it was appropriate for them to aim to maintain rather than increase their levels of physical activity. Others were not doing enough, but were not motivated to change, or wanted to improve their level of physical activity, but not through walking. Measuring participants' motivation and precise intentions at the start of the intervention might enable the most effective use of persuasive technology with flexibility in the activities undertaken and tailored goals to enable action.

As outlined in Chapter 4, the present research was conducted concurrently with the SMART 3 project, which aims to design a holistic self-management system for PwCOPD. The technology used in Study 3 will continue to be developed as part of the SMART 3 project. As such, some of the recommendations that have been made as a result of the findings reported in this thesis have already begun to be implemented in the second iteration of this persuasive technology. For example, positive goal performance discrepancies will be recorded and fed back, and the accuracy of the physical activity monitor will be assessed and improved. Future research, therefore, should first assess the impact of these changes on this population (those people who are attending maintenance classes) to assess whether the potential to change behaviour has been improved. From there a number of research avenues could be investigated. To find out more about this population, a greater understanding of how PwCOPD set goals following rehabilitation would be valuable, as would knowledge of the potential emotional effects, and effects on self-efficacy of achieving or not achieving these goals and how this impacts on the ability to self-regulate physical activity. A second research avenue would be to see if the findings here would be replicated in other populations of PwCOPD, for example, those who are unable or unwilling to attend PR. With increasing opportunities to connect personal devices to healthcare services, the implementation of this type of technology within the healthcare system should also be carefully considered. As technology becomes more advanced, the number of wearable devices, and the types of data that could be sent between PwCOPD and HCPs are increasing, in future research it will be important to keep addressing acceptability to all stakeholders and how the vast potential can best be realised to change health behaviours.

8.4 Reflective Discussion

This short section is designed to acknowledge the potential effect that the author has had on the findings reported here. For qualitative and quantitative analysis, judgements are made by the researcher, which may have been made differently if someone else had conducted the research. The choice of theories that have informed this work have been influenced by the researcher's background and training in health psychology and current position in health services research. For example, had this research been carried out by a physiotherapist, there may have been greater focus on improvements in exercise capacity than the act of behaviour change itself, and furthermore, different theories may have been used to explain the findings. The use of mixed methods in health services research is now well established (e.g. Broom & Willis, 2007; Bryman, 2007; Morgan, 2007; Scott & Briggs, 2009; Tariq & Woodman, 2013), although there are ongoing debates about how best to integrate the findings (e.g. Creswell, Plano Clark, & Garrett, 2008; O'Cathain, Murphy, & Nicholl, 2008; Sale & Brazil, 2004). The author's aim in the present research was that the findings should be applicable to a real-world setting. Therefore, while some internal validity may have been sacrificed by using a wide range of methods, this was balanced against increased external validity. Where this may have introduced bias, this has been discussed, so that the findings reported should not overstate the evidence they are drawn from.

As discussed above, participants can take different roles within a research study – they can also take different social roles within an interview. The difference in age between the participants and the thesis author, and the fact this research formed part of a PhD, may have influenced these roles. Participants may have been motivated to help the thesis author, to appear more socially desirable rather than being focussed on improving their self-management. Furthermore, some PwCOPD may not have felt comfortable talking to a younger adult about technology, especially if they perceived the thesis author as an 'expert'. This may have contributed to the sample recruited having relatively high technology use, and could have encouraged participants to answer more positively. The organisation INVOLVE, that advises on patient and public involvement in research, advocates the use of peer interviewers to overcome these problems, the idea being that interviewees are more likely to feel at ease with interviewers more similar to themselves (INVOLVE, 2014). However, identifying, and appropriately training, peer interviewers is time-consuming. Furthermore being present at the interview can add richness to the interpretation of the data. Obviously personal characteristics of the researcher cannot be changed, but being aware of them can help researchers to minimise the potential influence these characteristics may have. Fundamental to this is the importance of putting participants at their ease, rapport building, and being aware of body language and verbal cues that may imply discomfort or reticence. The interviews undertaken here were all conducted face to face, and the researcher spent at least an hour (and at times considerably more) in the participants' company. This time allowed a rapport to build and the impression given by participants was that they were at ease and happy to share their opinions, both positive and negative.

8.5 **Conclusions**

This thesis has explored the potential of persuasive technology to promote behaviour change in PwCOPD. The findings show that persuasive technology based on self-monitoring and goal-setting would be acceptable to a subset of the COPD population who are physically capable and motivated to both use technology and increase their activity levels. Two approaches to tailor persuasive technology and increase its acceptability have also been identified; setting goals that are appropriate to key user characteristics, and ensuring the role played by the technology addresses the user's needs. Improvements to the delivery of the behaviour change components have been discussed and some of these changes are already being implemented in the next iteration of this technology. The type of technology available to deliver behaviour change interventions will continue to change and improve. Therefore, the challenge for researchers in this field is to ensure that the capabilities of this technology are used in the most effective way to encourage behaviour change and improve the health of potential users. By building on previous behaviour change theories and research to understand why certain elements of the technology may have the desired effect, and others not, involving users in each step of the process, and objectively measuring behaviour change, health research and PwCOPD will continue to benefit from the potential persuasive technology presents.

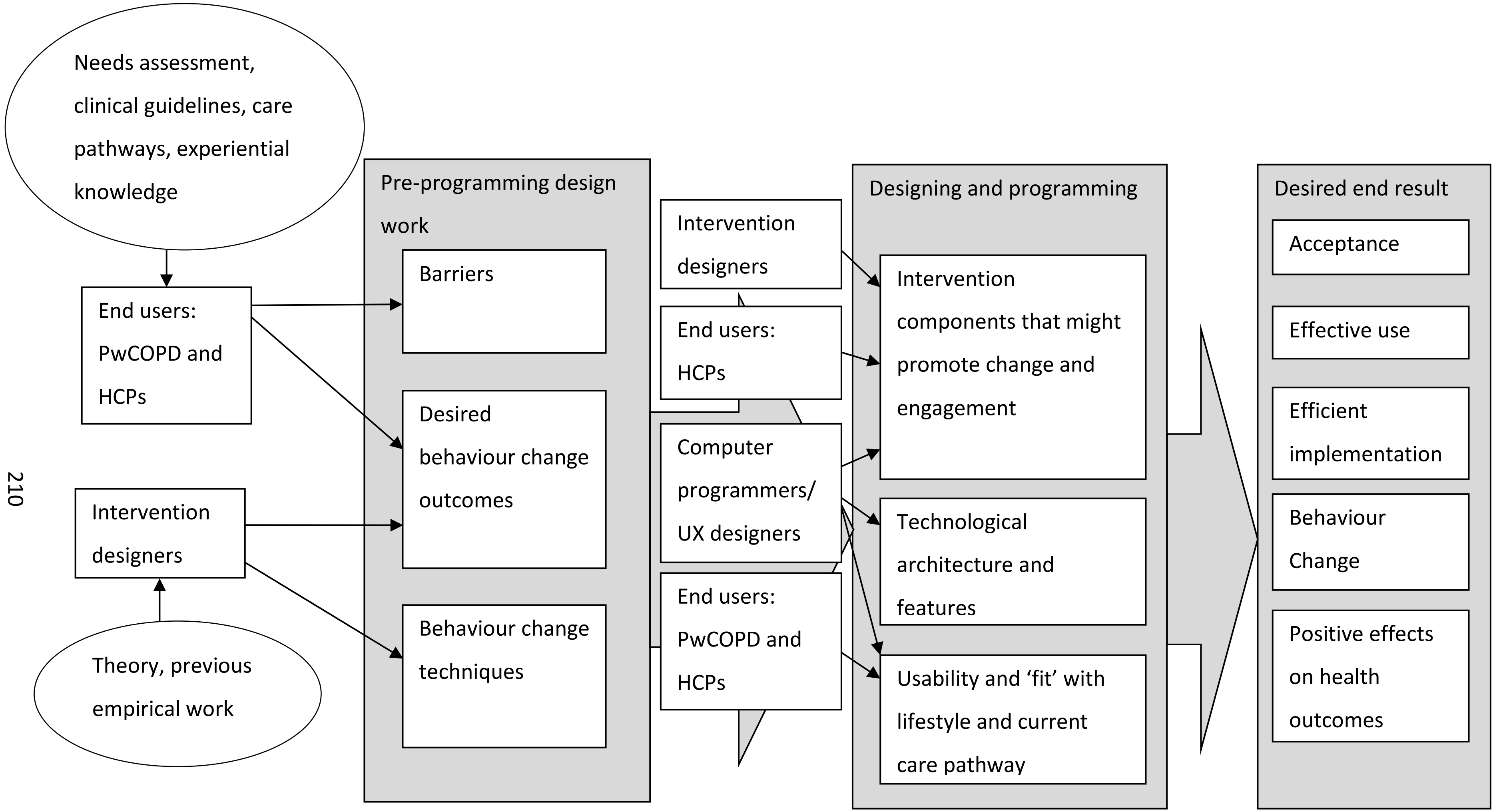

Figure 8.1: A suggested framework for interdisciplinary persuasive technology development

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Peer reviewed presentations and publications resulting from this work

Bartlett, Y.K., Sheeran, P. & Hawley, M.S. (2013) Effective behaviour change techniques in smoking cessation interventions for people with chronic obstructive pulmonary disease: A meta-analysis. *British Journal of Health Psychology.* Early view available Open Access at http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)2044-8287/earlyview

Bartlett, Y.K., Hawley, M.S., Sheeran, P. & Webb, T.L. (2013, September). *Could persuasive technology be used to increase physical activity in people with COPD? Opinions of the target population and other stakeholders*. Poster presented at the BPS DHP Annual conference, Brighton, UK

Other presentations resulting from this work

Bartlett, Y. K. (2014, March). *An overview of a PhD: Investigating using persuasive technology to encourage behaviour change in people with COPD.* Presentation at the Social Health and Educational Psychology group, University of Sheffield, Sheffield

Bartlett, Y. K. (2013, October). *Using persuasive technology to promote behaviour change*. Presentation to the teenage and young adults cystic fibrosis team, Northern General, Sheffield

Bartlett, Y.K. (2013, June). *Using persuasive technology to increase physical activity in people with COPD*. Presentation at Health devices: development and appraisal PhD student workshop, Czech Technical University, Prague, CZ.

Bartlett, Y. K. (2013, June) *Persuasive technology to increase physical activity in people with COPD: Opinions and preferences of key stakeholders.* Presentation at the ScHARR postgraduate conference, Sheffield

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Bartlett, Y. K. (2011, June) *Behaviour change techniques in smoking cessation interventions for people with COPD: A systematic review.* Presentation at the ScHARR postgraduate conference, Sheffield

3 Appendix I: For Chapters 1, 2 & 3

This Appendix shows descriptive and results tables and figures from the reviews reported in Chapters1, 2 and 3.

Table 1: Study details from the scoping review of technology use in COPD care, reported in Chapter 1

Table 2: Delphi List quality criteria, reproduced from Verhagen et al., 1998 used in the reviews reported in Chapters 2 and 3

Table 3: Intervention characteristics for the review of interventions targeting smoking cessation reported in Chapter 2

Table 4: Sample characteristics for the review of interventions targeting smoking cessation reported in Chapter 2

Figure 1: Funnel Plot for the review of interventions targeting smoking cessation reported in Chapter 2

Table 5: Intervention characteristics for the review of interventions targeting physical activity reported in Chapter 3

Table 6: Sample characteristics for the review of interventions targeting physical activity reported in Chapter 3

3.1 Table 1: Study details from the scoping review of technology use in COPD care

Study	Publication type	Aim	Hardware	Components	Key findings	Information transfer
Borycki & Kushniruk, 2007	Conference proceedings	To inform the development of a web-based self-management tool	Planned web-based self-management tool	In development	Qualitative analysis found PwCOPD had information needs related to self-management, the primary information need related to breathlessness	NR
Burkow et al., 2008	Journal article	Monitor symptoms and increase physical activity	PwCOPD: TV, camera, hub. HCPs: PC	PwCOPD can use their TV to conduct video consultations with their HCP, monitor their symptoms (physiologically and by questionnaire), watch instructional videos and take part in group exercise classes.	A field trial with PwCOPD confirmed the system was easy to use	Yes, tele-consultation
Cooper & O'Hara, 2010 Marno et al., 2010	2 Journal articles	Medication management	Automated telephone service	An automated telephone service provides weather warnings and advises PwCOPD to check they have enough medication, and go to the GP if necessary	The service was seen as appropriate (although there were concerns about reliability of forecasts) some evidence of the service improving self-management behaviours	None
Crespo, Morillo, et al., 2010; Crespo, Sanchez, et al., 2010	Conference proceedings	Symptom monitoring	PwCOPD: a phone/ videophone and a 'dedicated mobile device' (DMD). HCPs: an electronic health record	Provision of an electronic health record to PwCOPD and HCPs. Symptom monitoring to pick up early signs of an exacerbation (with voice recognition input), warning signals on the HCP system. PwCOPD can access social networks using the mobile device	Pilot demonstration with PwCOPD, high satisfaction with some system errors and errors with voice recognition	Data sent, tele-consultations if necessary
Cummings et al., 2010; Cummings & Turner, 2006	Conference proceedings and eBook chapter	Monitor symptoms	NR	Development of an electronic diary to monitor symptoms	PwCOPD who used the electronic diary maintained their involvement for longer than those using a paper diary,	Data sent

					both groups improved self-management	
Finkelstein, Khare, Vora, & Arora, 2003	Conference proceedings	Monitor symptoms and increase physical activity	PwCOPD: computer with physiological measuring device, server and clinician units (PDAs, computers, palmtops, netbooks, games console etc. have all been used for the patient units, clinician units are any device that can use the internet)	PwCOPD inputs physiological data as well as self-reported symptoms and medication use. Feedback and advice given by the system. COPD education is given, quizzes assess understanding and form part of the feedback/ alert system Counselling to encourage behaviour change given by the system based on improving behavioural capability, self-efficacy and outcome expectations and providing reinforcement (based on the social cognitive theory) Social support is given via online support groups and direct communication with a social worker The option to use the web cam to videoconference with a range of HCPs to receive a remote consultation, psychotherapy, exercise supervision etc.	Focus groups of PwCOPD largely reported that the system was usable and acceptable, some PwCOPD were fearful of technology, if this could not be overcome the system was not acceptable.	Data sent and tele-consultations, PwCOPD can also message HCPs
Fitzsimmons et al., 2011	Journal article	Monitor symptoms	Telehealth system	PwCOPD enter symptom information (physiological and self-report) into the telehealth monitoring system. Alerts are sent to HCPs	NR, protocol	Data sent and alerts generated
Johnston, Nguyen, & Wolpin, 2009	Journal article	Increase physical activity	Mobile device and website	Designing an exercise tracking service as part of a larger breathlessness management service. PwCOPD input symptoms and exercise data on the mobile device or the computer Output on the website (goals, activities	In a focus group participants favoured a calendar display of activities completed, visible goals, and thought feedback related to goal attainment would motivate them. Once developed, think aloud usability	Data sent and alerts generated

				completed and line graphs of symptoms) Alerts sent to HCPs and PwCOPD if symptoms exceed pre-defined thresholds	testing conducted (n=3), participants worked through scenarios given by researchers and rated the system Overall positive results, percentage of exercise complete was however incorrectly interpreted by most participants Further development planned	
Koff et al., 2009	Journal article	Monitor symptoms	Telehealth system (Health Buddy©)	PwCOPD provides physiological data and symptom data from questionnaires, undertakes an education session. The Health Buddy system transmits data to HCPs for review and generates alerts as needed. PwCOPD also had access to a 'study coordinator' (respiratory therapist) for help and advice over the phone. Any medical queries that couldn't be answered, were forwarded onto the patient's physician	Tested in a clinical RCT. Statistically significant improvement in health related Quality of Life (measured by the SGRQ) in the group receiving proactive integrated care as appose to usual care. Nine exacerbations correctly identified by the Health Buddy system, only 2 patients rang the study coordinator however, 7 waited and were contacted the next day. Authors suggest this might be due to patients not perceiving the importance of exacerbations, or over-reliance on the monitoring equipment. High satisfaction with the equipment was reported	Data sent and alerts generated
Liu et al., 2008	Journal article	Increase physical activity	Mobile phone, optional headphones	PwCOPD were given music on a phone with a tempo that would encourage walking at 80% of their exercise capacity. PwCOPD were asked to walk with the music playing until they could	In a small pilot study, significant improvements were found in ISWT. Also greater inspiratory capacity, QoL, fewer exacerbations and	Data sent to HCPs, discussed at consultations.

				no longer keep up, and complete daily symptom questionnaires	hospitalisations than a control group.	
Mair et al., 2005	Journal article	Monitor symptoms	Videophone	PwCOPD measured physiological symptoms and had a tele-consultation with a HCP.	Asked both PwCOPD and HCPs to rate the tele-consultation, PwCOPD were more positive about the experience than PwCOPD.	Data sent, tele-consultation.
Medvedev et al., 2008	Conference presentation		Planned smart phone application with monitoring devices connected via bluetooth	Aims to improve self-management in a range of chronic conditions. Pulmonary rehabilitation will be monitored by pulse oximetry and activity monitors	None	NR
Moy et al., 2010	Journal article	Increase physical activity	Pedometer and website	PwCOPD wear a pedometer and enter a daily step count to the website. The system sets a step count goal for each week based on the average of the last 7 step counts uploaded, increased by 800 steps every week. Motivational messages given	Accuracy of the Omron HJ-720ITC pedometer evaluated, captured 80% of steps in COPD patients Number of steps walked significantly improved for COPD patients over 16 weeks using the system A social element has been added, with the ability to send messages between users, this element is currently being evaluated.	None
Nguyen et al., 2008	Journal article	Monitor symptoms, decrease breathlessness and increase physical activity	PDA and website	Initial consultation to provide an exercise plan and exacerbation action plan, education given related to dyspnoea and coping with it. PwCOPD input symptom and exercise information daily. Goals are set. HCP	Comparison of the internet system, with a face-to-face version Technical problems with the system resulted in the early termination of recruitment,	Data sent, alerts generated

				then reviews information and provides feedback. Weekly live chat sessions with other participants and the study nurse The internet system has alerts for nurses if symptoms worsen	enrolled participants were followed for the duration. Results showed improvements in dyspnoea over time for both groups, but no difference between face-to-face and internet delivered.	
Nguyen et al., 2009	Journal article	Increase physical activity	Touchscreen mobile phone and pedometer	Action plan decided with physician Exercises and symptoms self-reported with the cell phone, cell phone reminds patient by beeping when data needs to be input. Data from pedometer input by patient. Nurses monitor daily and respond to any alerts by text message or phonecall MOBILE- C (Coached) condition patients sent motivational messages by the nurse tailored to activity performance MOBILE –SM (Self-monitoring) alerts disabled, standard messages weekly thanking users for continued input.	Pilot testing with 17 PwCOPD. Problems included phones losing signal, and participants not carrying them as they already owned a phone. SM group improved more than the coached. Unclear why but authors suggest due to the small numbers tested.	Data sent, alerts generated, coaching messages from HCPs in one condition.
Paget et al., 2010	Journal article	Monitor symptoms	Telehealth system	PwCOPD monitored physiological symptoms, data was sent to HCPs and was also available for PwCOPD to print out	Pilot study. Technical faults led to equipment having to be replaced, in some cases PwCOPD declined the new equipment due to the problems. Full analysis has not been completed but initial analysis showed PwCOPD liked the system, and found it easy to use.	Data sent, HCP reviews and decides if any action needs to be taken. PwCOPD can request a HCP visit.
Pinnock et al.,	Journal article	Monitor	Tablet	PwCOPD to monitor symptoms with	Protocol	Data sent,

2009		symptoms	computer	diary cards. The tablets have the capability to support tele-consultations		HCPs review and decide if action is needed. Able to have teleconsultations.
Selecky, 2008	Journal article	Monitor symptoms, encourage other self-management behaviours	Either a computer or a telephone	PwCOPD monitor symptoms and send them over the phone or internet to HCPs. HCPs provide feedback, flag potential problems and provide coaching in different aspects of self-management e.g. physical activity, or palliative care	NR, description of the service provided.	Date sent, HCPs review and take action.

3.2 Table 2: Delphi List quality criteria, reproduced from Verhagen et al., 1998 used in the reviews reported in Chapters 2 and 3

Quality Criteria	*Response*
Was a method of randomization performed?	Yes/No/Don't know
Was the treatment allocation concealed?	Yes/No/Don't know
Were the groups similar at baseline regarding the most important prognostic indicators?	Yes/No/Don't know
Were the eligibility criteria specified?	Yes/No/Don't know
Was the outcome assessor blinded?	Yes/No/Don't know
Was the care provider blinded?	Yes/No/Don't know
Was the patient blinded?	Yes/No/Don't know
Were point estimates and measures of variability presented for the primary outcome measures?	Yes/No/Don't know
Did the analysis include an intention-to-treat analysis?	Yes/No/Don't know

3.3 Table 3: Intervention characteristics for the review of interventions targeting smoking cessation reported in Chapter 2

Reference	*Country*	*BCTs used in intervention*	*BCT category (n)*	*SSM*	*Comparison*	*Duration*	*Longest follow-up*	*Session description*	*Delivery*	*Setting*
Anthonisen et al.,1994[1]	USA	BM1, BM3, BM12 BS2, BS3, BS4, BS6, BS10, BS13, A1, A2, A3, A4, A5, RD1, RD2, RI1, RI2, RI10, RC1, RC4, RC5, COPD Med, COPD Spec	4	Yes	Usual Care	5 years	5 years	1 meeting with physician,1 orientation meeting, 12 group meetings over 10 weeks, 4 per week, then declining in frequency. Minimum monthly maintenance visits until participant remained abstinent for 8 months (through 2 follow-up visits). 15 follow-up visits, every 4 months for 5 years. Further opportunities to attend sessions as needed.	One to one and group	Clinic
Borglykke et al.,2008 [2]	Denmark	BM1, BM2, BM11, BS2, BS3, BS4, BS13, A1, A2, A3, A5, RD1, RD2, RI2, RI5	4	No	Usual Care	5 weeks	1 year	5 weekly group sessions of 2 hours	Group	Hospital
Brandt et al., 1997	Denmark	BM2, RI1, COPD med, COPD spec, COPD/smoke link	2	No	Usual Care	NR	1 year	Every time the medical staff spoke to the participant about their illness in the time they were at hospital, and	One to one	Hospital

Reference	*Country*	*BCTs used in intervention*	*BCT category (n)*	*SSM*	*Comparison*	*Duration*	*Longest follow-up*	*Session description*	*Delivery*	*Setting*
								all the materials they received		
Christenhusz et al.,2006	Netherlands	BM2, BM4, BM6, BM7, BM9, BM10, BS1, BS2, BS5, BS8, BS11, BS14, A1, A2, A3, A5, RD1, RD2, RI2, RI7, RC1, RC8, COPD spec	4	Yes	Usual Care	NR	1 year	Four small-group meetings (total 6 hours), four individual sessions (total 195 minutes), four telephone contacts (total 40 minutes)	One to one and group	Home. Unclear for group sessions
Crowley et al.,1995	USA	BM2, BM3, BM6, BM7, BM12, BS2, BS3, BS4, BS8, A1, A2, A3, RI1, RI2, RI5, RC4,RC3, RC5,RC6	4	No[7]	Rewarded but dependant on a yoked control's smoking behaviour, not their own.	86 days	6 months	On each of 86 days, a researcher guided by manual visited the participants' home.	One to one	Home
Efraimsson et al., 2008	Sweden	BM9, RD1, RI10, COPD med, COPD spec	2	No	Usual Care	3-5 months	3-5 months	2 visits to the COPD clinic, 2 visits for self-care education with a nurse.	One to one	Clinic
Hilberink et al.,2011	Netherlands	BM1, BM2, BS1, BS2, BS4, A1,	4	No[8]	Usual Care	NR	1 year	Unclear (dependant on motivational stage,	One to one	GP practice

Reference	*Country*	*BCTs used in intervention*	*BCT category (n)*	*SSM*	*Comparison*	*Duration*	*Longest follow-up*	*Session description*	*Delivery*	*Setting*
		A5, RD1, RI5, RC5, COPD spec.						maximum of 2 follow-up visits and 3 follow-up phone calls)		and home
Khdour et al.,2009	UK	BM9, A5, RI1,COPD med, COPD spec	3	No	Usual Care	1 year	1 year	3 outpatient clinic appointments and 2 phone calls	One to one	Pharmacy and Home
Kotz et al. , 2009[3]	Netherlands	BM1, BM2, BM3, BM10, BS1, BS2, BS3, BS4, BS5, BS6, A1, A4, RD2, RI1, RI2, RI3, RI5, RI7, RI10, RC1, RC2, RC4, RC5, RC6, RC7, RC8, RC9, RC10, COPD smoking link	4	Yes	Usual care[9]	22 days	1 year	4*40 minute sessions 3 face to face and 1 telephone	One to one	Clinic and home
Pederson et al.,1991	USA	BM2, BM10, BS2, BS3, BS6, RD1, RI9, RC2, RC5, RC6, RC8	3	No	Usual Care	Duration of hospital stay	6 months	1 initial, then 2 to 8 follow-up sessions while at hospital.	One to one	Hospital
Sundblad et al.,2008	Sweden	BM1, BM2, BM3, BM7 ,BS1, BS3, BS4 BS6, BS13, A1, A2, RD1, RI1, RI9, RC6, COPD spec.	4	No	Usual care	1 year	3 years	11 hours with a smoking cessation nurse, then education sessions during one 2-week period of admission, a further 2 - 4 days admission if agreed to. Then 24-28 follow-up phone calls lasting 5 - 30 minutes	One to one and group	Hospital and Home

Reference	*Country*	*BCTs used in intervention*	*BCT category (n)*	*SSM*	*Comparison*	*Duration*	*Longest follow-up*	*Session description*	*Delivery*	*Setting*
Tashkin et al., 2001	USA	BM2, BS2, BS4, BS6, BS8, A3, RD1, RD2, RI1	4	Yes	Placebo	12 weeks	6 months	9 face-to-face sessions at clinic visits, 1 telephone counselling, diaries completed everyday so a further 84 self-directed sessions	One to one	Clinic and Home
Tashkin et al., 2011[5]	USA/Spain/France & Italy	BM1, BM2, BM4, BM6, BM8, BM11, BS1, BS3, BS4, BS5, BS7, BS11, A1, A2, A4, A5, RD1, RD2, RI1, RI2, RI3, RC4, RC5, RC6, RC8, RC10	4	Yes	Placebo	1 year	1 year	In the 12-week treatment phase participants visited the clinic 12 times (weekly) and were telephoned once; in the follow-up phase (no pharmacological treatment, brief counselling at every visit and phone call) participants visited the clinic 7 times and were telephoned 5 times.	One to one	Clinic and Home
Tønnesen et al.,2006	Denmark	BM1, BS2, A1, A3, RI1, RC5, RC6, COPD smoke link	4	Yes	Placebo	12 weeks	1 year	Low support condition: 4*20-30-min visits, 6*10-min phone calls. High support condition:7*20-30-min visits, 5*10-min phone calls.	One to one	Clinic and Home
Wagena et al., 2005	The Netherlands	BM4	1	Yes	Placebo	12 weeks	26 weeks	Baseline visit, 10-20 minutes face-to-face counselling at weeks 1, 3 and 12 post quit	One to one	Clinic and Home

Reference	Country	BCTs used in intervention	BCT category (n)	SSM	Comparison	Duration	Longest follow-up	Session description	Delivery	Setting
								date. Supportive telephone calls on the quit date and 2, 5, 6, 8 and 11 weeks post quit date.		
Wilson et al., 2008 [4]	UK	BM1, BM2, BM10, BS1, BS2, BS4, A1, A2, A3, A5, RD1, RI1, RI2, RI3, RI7, RC1, RC5, RC8	4	No	Usual Care	5 weeks	1 year	Up to a maximum of 5*60min sessions, depending on the experimental group	One to one or group dependin g on the experime ntal condition	Clinic
Zwar et al., 2012[6]	Australia	BM2, BM3, BM9, BS1, BS3, BS4, BS5, A5, RI1, RI2, RI5, RI10	4	No	Usual Care	26 weeks	1 year	Initial home visit with spirometry. Collaborative work with nurse, GP and patient to implement the plan, including at least 2 home visits, 5 phone call and two GP visits. Including referring to external sources for pulmonary rehab and smoking cessation.	One to One	GP Practice and Home

Note: Additional BCT information coded from: [1] O'Hara, Grill, Rigdon, Connett et al., 1993 [2] Kjaer, Evald, Rasmussen, Juhl et al., 2007 [3] Kotz, Wesseling, Huibers, & van Schayck, 2007[4] Raw, McNeill, & West, 1998 [5]Fiore, Jaen, & Baker, 2008.[6] Additional information from online supplement, email response and Zwar, Hermiz, Hasan, Comino et al., 2008 [7]NRT was given to both intervention and control group, used at participants discretion, not a mandatory part of the intervention [8]Although Hilberink et al., stated provision of SSM was part of their protocol, they reported that very few participants took the medication suggested, as this was reported this study has been coded as not containing SSM [9] Non-confrontational counselling group not reported here BM1: Provide information on the health consequences of smoking and smoking cessation; BM2: Boost motivation and self-efficacy; BM3: Provide feedback on current behaviour and progress; BM4: Provide rewards contingent on not smoking; BM6: Prompt commitment from the client there and then; BM7: Provide rewards contingent on effort or progress; BM8: Strengthen ex-smoker identity; BM9:Conduct motivational interviewing BM10: Identify reasons for wanting and not wanting to stop smoking; BM11: Explain the importance of abrupt cessation; BM12: Measure carbon monoxide (CO); BS1: Facilitate barrier identification and problem solving; BS2: Facilitate relapse prevention and coping; BS3: Facilitate action planning/ develop a treatment plan; BS4: Facilitate goal setting; BS5: Prompt review of set goals; BS6: Prompt self-recording; BS7:Advise on changing routine; BS8: Advise on environmental restructuring; BS10: Advise on conserving mental resources; BS11:Advise on avoidance of social cues for smoking; BS13: Advise on methods of weight control; BS14: Teach relaxation techniques; A1: Advise on stop smoking medication; A2: Advise on/facilitate use of social support; A3: Adopt appropriate local procedures to enable clients to obtain free medication ; A4: Ask about experiences of stop smoking medication that the smoker is using ;A5: Give options for additional and later support; RD1: Tailor interactions appropriately; RD2: Emphasise choice; RC1: Build general rapport; RC2: Elicit and answer questions; RC3: Explain the purpose of carbon monoxide monitoring ; RC4: Explain expectations regarding treatment programme ; RC5: Offer/direct towards appropriate written materials; RC6: Provide information on withdrawal symptoms; RC7: Use reflective listening; RC8: Elicit client views ; RC9: Summarise information / confirm client decisions; RC10: Provide reassurance; RI1: Assess current and past smoking behaviour; RI2: Assess current readiness and ability to quit ;RI3: Assess past history of quit attempts; RI4: Assess withdrawal symptoms; RI5: Assess nicotine dependence; RI6: Assess number of contacts who smoke; RI7: Assess attitudes to smoking; RI9: Explain how tobacco dependence develops; RI10: Assess physiological and mental functioning.

3.4 Table 4: Sample characteristics for the review of interventions targeting smoking cessation reported in Chapter 2

		Mean (SD) Age		*Mean (SD)FEV_1% predicted*[†] *at baseline*	
Authors	*Female %*	*Experimental*	*Control*	*Experimental*	*Control*
Anthonisen et al.,1994	37.13	48.4 (6.8) [a]	48.4 (6.9)	75.1%[a](8.8)	75.1% (8.8)
Borglykke et al.,2008	64.57	65 (NR)	67 (NR)	NR	NR
Brandt et al.,1997	NR	66 (range 38-88)[b]	66 (range 38-88)[b]	NR	NR
Christenhusz et al.,2006	47.56	59.6 (8.51)	57 (8.41)	62.8 (25.7)	65.6 (27.4)
Crowley et al.,1995	24.24	62.3 (NR) [c]	63 (NR)	NR	NR
Efraimsson et al., 2008	50	66 (9.4)	67 (10.4)	NR	NR
Hilberink et al.,2011	50.97	60.7(11.2)[d]	60.1 (11.5)[f]	NR	NR
Khdour et al.,2009	56.1[e]	65.63(10.1)[e]	67.3 (9.2)[e]	52(15.9)[e]	52(17.8)[e]
Kotz et al. , 2009	39.67	53.8 (7.0)	53.0 (7.6)[f]	80.5(14.7)	79.7(14.0)[f]
Pederson et al.,1991	31.08	53.4 (13.7)[b]	53.4 (13.7)[b]	NR	NR
Sundblad et al.,2008	50.34	53 (range 41-62)	52 (range 41-61)	74(16)	77(14)
Tashkin et al., 2001	45.01	53.2 (9.0)	54.5 (9.5)	73.2(19.4)	69.4(17.3)
Tashkin et al., 2011	37.68	57.2(9.1)	57.1(9.0)	70.8(17.0)	69.1 (16.9)
Tønnesen et al.,2006	52.16	59.2 (10.3)[g] 61.3 (9.6)[i]	62.5(9.3)[h] 61.2 (9.4)[j]	73.4(17.5)[g] 71.3(19.2)[i]	73.8(20.9)[h] 73.1(16.4)[j]
Wagena et al., 2005	51(8.5)[e]	51.1(8.3)[k] 51.2(9.1)[l]	51.3 (8.4)[k]	NR	NR
Wilson et al., 2008	51.65	61(84)[b]	61(84)[b]	NR	NR
Zwar et al., 2012	52.11[e]	65.8 (10.3)[e]	64.4(10.3)[e]	NR	NR

Note: [†]Forced Expiratory Volume in one second, presented as a % of what would be expected for someone of the same age, gender and height (FEV_1%pred) [a] Bronchodilator vs. Usual care; [b] Group ages not reported, average across groups; [c] Experimental and Control; [d] Counselling, Nicotine replacement and Buproprion Group; [e] For the whole sample, not only smoking people with COPD; [f] Usual care [g] Nicotine and low support; [h] Placebo and low support; [i] Nicotine and High support; [j] Placebo and high support; [k]Bupropion ; [l] Nortriptyline; [k] Placebo; NR= Not Reported.

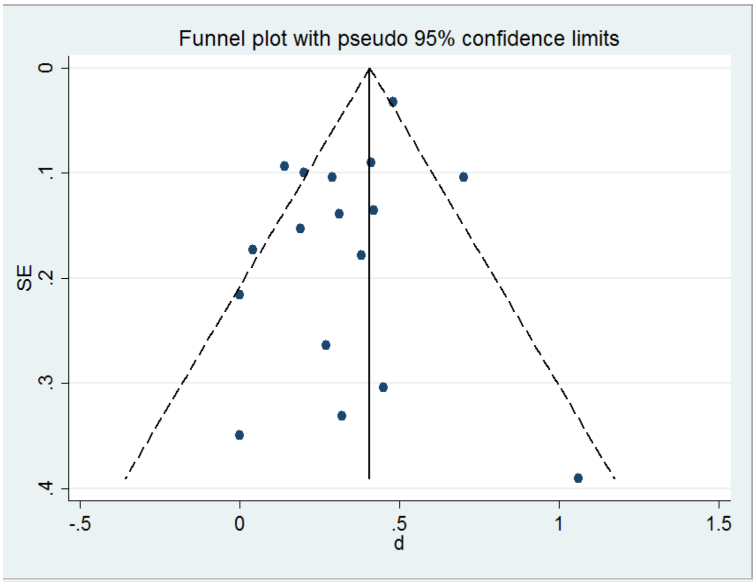

Figure 1: Funnel Plot for the review of interventions targeting smoking cessation reported in Chapter 2

3.5 Table 5: Intervention characteristics for the review of interventions targeting physical activity reported in Chapter 3

Study	*Supervised exercise*	*Recommended unsupervised exercise*	*Control group included exercise component*	*Previous rehabilitation attendance*	*Supervised sessions*	*Unsupervised sessions*	*Order of sessions*	*Duration to longest follow up (weeks)*	*BCTs (n)*
Bauldoff et al., 1996	Incremented upper arm exercise	Incremented upper arm exercises	No	NR	8	40	Concurrent	8	7,8,12 (3)
Bauldoff et al., 2002	Walking	Walking	Yes	Not in the previous 6 months	1	29	Training only	8	0
Beckerman et al., 2005	Inspiratory muscle training	Inspiratory muscle training	Yes	None were currently engaged in regular physical activity	108	674	Concurrent	52	0
Behnke et al., 2000	Walking	Walking	No	NR	16	508	Consecutive	26	8,12,26, COPD spec (4)
Berry et al., 2010	Walking and strength training	Walking, strength training and general physical activity increase	Yes	Not in previous 3 months	11	156	Consecutive	52	5,10,11, 12,14,17,19,20, 21,26 (10)
Bestall et al., 2003	Upper and lower limb training, aerobic (walking and cycling)	NS encouraged to exercise between 3 and 5 times per week and use a diary card	No	NR	12	208	Concurrent	52	7,8,10,12 (4)
Bjornshave	Stair climbing	Stair climbing	Yes	NR	1	20	Training only	4	0

Study	*Supervised exercise*	*Recommended unsupervised exercise*	*Control group included exercise component*	*Previous rehabilitation attendance*	*Supervised sessions*	*Unsupervised sessions*	*Order of sessions*	*Duration to longest follow up (weeks)*	*BCTs (n)*
and Korsgaard, 2005									
Breyer et al., 2010	Nordic walking	Nordic walking	No	NR	1	36	Training only	12	9 (1)
Brooks et al., 2002	Breathing exercises, interval training, upper limb training, walking/ cycling	Breathing exercises, upper extremity exercises, walking and interval training	Yes	Completed PR as a run-in to the study	29		Concurrent	52	17 (1)
Carrieri-Kohlman et al., 1996	Walking	Walking	Yes	Not in the last 6 months	12	32	Consecutive	12	4,9,13,17,24 (5)
Donesky-Cuenco et al., 2009	Yoga	Yoga	No	Not in the last 6 months	24	60	Concurrent	12	8,9,17 (3)
duMoulin et al., 1996	Cycling, walking, arm cycling, trunk, upper and lower limb strengthening	Walking	Yes	Completed PR as a run-in to the study	15	168	Consecutive	26	8,10,12 (3)
Faulkner et al., 2010	Aerobic and strength exercises	Aerobic and strength exercises	No	Never participated in PR	8	NR	Concurrent	14	1,2,4,5,7,8,12,19,20 (9)
Finnerty et al., 2001	Diagonal arm raises, arm abduction into elevation and reverse, arm	Walking	No	Never participated in PR	12	252	Concurrent	24	4,5,8,10,20,24, COPDspec (7)

Study	*Supervised exercise*	*Recommended unsupervised exercise*	*Control group included exercise component*	*Previous rehabilitation attendance*	*Supervised sessions*	*Unsupervised sessions*	*Order of sessions*	*Duration to longest follow up (weeks)*	*BCTs (n)*
	abduction, forward flexion and reverse, treadmill or bike, step ups and straight leg raises								
Ghanem et al., 2010	Breathing training, walking or cycling, upper and lower limb strength training	Breathing training, walking or cycling, upper and lower limb strength training	No	NR	1	28	Consecutive	8	8, 10, COPD spec (3)
Guell et al., 2000	Breathing training, cycling, arm leg coordination	Walking or cycling, stepping, arm leg coordination	No	Completed PR as a run-in to the study	108	NR	Concurrent	104	1,7,8,19,20,24,COPDspec (7)
Hernandez et al., 2000	Walking	Walking	No	NR	1	72	Training only	12	10,18 (2)
Hospes et al., 2009	Walking	Walking	No	Unwilling or unable to participate in PR	0	84	Instruction only	12	4,8,10,11,12,13,25,26 (8)
McGavin et al., 1977	Stair climbing	Stair climbing	No	NR	0	95	Instruction only	12	7,8,10,11,12 (5)
Nguyen et al., 2008	Endurance exercise and arm strengthening	Walking, cycling or swimming and arm strengthening	Yes	Not in the last 12 months	0	168	Instruction only	26	0
O'Shea et al.,2007	Hip abduction, simulated lifting, sit to stand,	Hip abduction, simulated lifting, sit to stand,	No	Not in the last 12 months	12	24	Concurrent	24	7,8,12 (3)

Study	*Supervised exercise*	*Recommended unsupervised exercise*	*Control group included exercise component*	*Previous rehabilitation attendance*	*Supervised sessions*	*Unsupervised sessions*	*Order of sessions*	*Duration to longest follow up (weeks)*	*BCTs (n)*
	seated row, lunges and chest press with resistance arm bands	seated row, lunges and chest press with resistance arm bands							
Oh et al., 2003	Breathing training, stretching, walking, stair climb, upper and lower limb strength training using resistance bands	Breathing training, stretching, walking, stair climb, upper and lower limb strength training using resistance bands	No	NR	0	280	Instruction	8	5,7,8,10,11,24 (6)
Riera et al., 2001	Breathing training	Breathing training	No	NR	24	120	Consecutive		8,12,13 (3)
Ries and Moser et al., 1986	Breathing training	Breathing training	Yes	Recruited from the wait list for PR	8	168	Concurrent	6	0
Ringbaek et al., 2010	Walking and cycling	Walking and cycling	Yes	Completed PR as a run-in to the study	39	504	Concurrent	76	5,18 (2)

Study	*Supervised exercise*	*Recommended unsupervised exercise*	*Control group included exercise component*	*Previous rehabilitation attendance*	*Supervised sessions*	*Unsupervised sessions*	*Order of sessions*	*Duration to longest follow up (weeks)*	*BCTs (n)*
Spencer et al., 2010	Walking, cycling, arm cycling, upper and lower limb strength training	Walking, upper and lower limb strength training	Yes	Completed PR as a run-in to the study	52	208	Concurrent	52	0
Waterhouse et al., 2010	Thoracic rotations, step ups, shoulder punches, knee lifts, snow angels, sit to stand, bicep curls, walking, sweeping, knee extensions, lifting and pegging washing	Thoracic rotations, step ups, shoulder punches, knee lifts, snow angels, sit to stand, bicep curls, walking, sweeping, knee extensions, lifting and pegging washing	Yes	Completed PR as a run-in to the study	12	NR	Concurrent	76	11,14,18 (3)
Yeh et al., 2010	Tai chi	Tai chi	No	Not currently participating in PR, but can have previously	12	36	Concurrent	12	4,9,12,24 (4)

3.6

3.7 Table 6: Sample characteristics for the review of interventions targeting physical activity reported in Chapter 3

Study	*Age Mean (SD)*		*FEV^{1} % predicted*	
	Experimental	*Control*	*Experimental*	*Control*
Bauldoff et al., 1996	61(14)	63 (13)	40.42 (15.59)	42.45(10.45)
Bauldoff et al., 2002	68.1 (8) overall	68.1 (8) overall	27(16)	37(18)
Beckerman et al., 2005	67.7(16.49)	66.9(15.11)	42(11.91)	43(11.45)
Behnke et al., 2000	exp 64 (1.9)	68.0 (2.2)	34.1 (7.4)	37.5 (6.6)
Berry et al., 2010	66 (10)	66(10)	50.5 (20.2)	53 (18.5)
Bestall et al., 2003	exp 68.2 (8.4)	69.2(6.3)	37 (11)	38 (12)
Bjornshave and Korsgaard, 2005	62 (95% C.I. 60-65)	63 (95% C.I. 59-66)	42 (95% C.I. 31-53)	29 (95% C.I. 22-38)
Breyer et al., 2010	61.9 (8.87)	59.0 (8.02)	48.1 (19.1)	47.1 (16.3)
Brooks et al., 2002	68(6.69)	68(7.62)	32(11.55)	32(11.09)
Carrieri-Kohlman et al., 1996	exp 68 (7)	66 (9)	40 (11)	36(10)
Donesky-Cuenco et al., 2009	72.2 (6.5)	67.7 (11.5)	51.2 (10.5)	44.4(19.0)
duMoulin et al., 1996	67 (7.26)	72 (6.45)	58.6 (6)	62.5 (6)
Faulkner et al., 2010	NR	NR	NR	NR
Finnerty et al., 2001	70.4 (8.0)	68.4 (10.4)	41.2 (19.2)	41.2 (16.2)
Ghanem et al., 2010	56.96(11.59)	56.43(9.03)	29.44 (13.14)	23.21 (7.70)
Guell et al., 2000	64(7)	66(6)	exp 31(12)	39(14)
Hernandez et al., 2000	64.3 (8.3)	63.1 (6.9)	41.7 (15.6)	40 (16.4)
Hospes et al., 2009	63.1(8.3)	61.2 (9.1)	67.4 (17.5)	61.8 (14.4)
McGAvin et al., 1977	61.4 (5.6)	57.2 (7.9)	NR	NR
Nguyen et al., 2008	68 (8.3)	70.9(8.6)	49.0 (16.8)	50.3(17.6)
O'Shea et al.,2007	64.8(7.84)	66.8 (12.29)	42.12(15.07)	44.91(17.75)
Oh et al., 2003	66.9(7.0)	68.4 (9.9)	49 (25)	52(22)
Riera et al., 2001	67 (4)	67.6 (5)	38.3(13)	41.3(11)
Ries and Moser et al., 1986	62(6)	67(10)	NR	NR
Ringbaek et al., 2010	66.7 (10.6)	69.2 (8.5)	35.6(14.0)	36.9(16.0)
Spencer et al., 2010	65 (8)	67 (7)	exp 57 (21)	60 (16)
Waterhouse et al., 2010[1]	68.7 (8.3)	69.1 (7.5)	45.1 (16.3)	48.3 (19.3)

Yeh et al., 2010	65 (6)	66 (6)	53 (7)	47 (7)

[1] Sample characteristics reported for hospital and community pulmonary rehabilitation groups as not reported for phone follow-up and usual follow-up

4 Appendix II: for Chapters 4 & 5

This Appendix contains all the supporting documentation for Study 3, the series of mixed methods *N*-of-1 studies.

i. A review of the barriers and facilitators of physical activity performance in PwCOPD
ii. Information sheet and consent form
iii. Ethics and R&D approval letters
iv. Exit interview topic guide
v. Demographic questionnaire

i. A scoping review of the barriers to and facilitators of performing physical exercise for PwCOPD

As outlined in Chapter 3, the pathway to sustained physical activity for PwCOPD is not straightforward, and there are many opportunities to enter back into the negative cycle of ever reducing levels of physical activity (Bourbeau, 2009b). At each of these opportunities, a variety of factors will influence the decisions made and the behaviour performed. As introduced in Chapter 1, the best practice guidelines recommend that PwCOPD attend pulmonary rehabilitation (PR), then ideally, PwCOPD will maintain an appropriate level of activity when the course ends. The systematic review and meta-synthesis reported in Chapter 3 identified what BCTs might be associated with more effective interventions, but did not provide any information about what might prevent PwCOPD performing physical activity. To review a range of data from both qualitative and quantitative sources a scoping review was chosen rather than a systematic review to gain a broad overview of the topic area. The review was conducted according the steps outlined by Armstrong and colleagues (Armstrong et al., 2011).

To gain further understanding of the target behaviour and population (physical activity in PwCOPD), the identified barriers and facilitators will be classified according to the COM-B model. This model forms part of the Behaviour change Wheel (BCW) approach to designing interventions and classifies the 'sources of behaviour' as being Capability (either physical or psychological); Opportunity (either social or physical); or Motivational (either automatic or reflective), see Chapter 1 for an overview of this approach. The definitions used to categorise the barriers and facilitators, were those provided by Michie et al., 2011. Capability is defined as an 'individual's psychological and physical capacity to engage in the activity concerned'; and this is divided into their 'physical ability to perform behaviour' and their psychological 'capacity to engage in the necessary thought processes'. Opportunity is defined as 'the factors that lie outside the individual that make the behaviour possible or prompt it'; split into the physical 'opportunity afforded by the environment', and the social 'opportunity afforded by the cultural milieu that dictates the way we think about things'. Finally motivation is defined as 'Brain processes that energise and direct behaviour'; split into reflective: 'involving evaluations and plans', and automatic: 'involving emotions and impulses that arise from associative learning/ or innate dispositions' (Michie, et al., 2011, p.4). The COM-B postulates that in order for a behaviour to be performed a person must be capable (both physically and psychologically), have the opportunity (both physically and socially) and be motivated (on both an automatic and reflective level). A barrier can occur in any one of these categories, for example someone may be physically able and motivated to be physically active, but find it embarrassing when they get breathless in public. Offering this person a social opportunity to be physically active with other people who experience breathlessness may help this person perform the desired behaviour.

4.1.1 Methods

Search terms relating to COPD, beliefs and physical activity were used (see Box 2). The search was completed in WoK (all databases inc. Web of Science and MEDLINE), PsycINFO, EMBASE and CINAHL on 28/11/2011. Papers were included if they a) sampled PwCOPD, or if multiple conditions, the results were separated by condition, b) identified barriers or facilitators or predictors of levels of physical activity, and exercise performance or maintenance or adherence and c) were written in English. Papers were excluded if they were exclusively focused on PR related activity i.e. accepting a PR referral, adhering to PR, and performance during PR. If the same data were presented in more than one eligible paper, the most up to date was retained.

Box 2. Search Strategy for Barriers and Facilitators Review

#1 Topic=(COPD) OR Topic=(Bronchial diseases) OR Topic=(pulmonary emphysema)
#2 Topic=(chronic bronchitis) OR Topic=(pulmonary disease chronic obstructive) OR Topic=(chronic obstructive pulmonary disease)
#3 Topic=(lung diseases obstructive) OR Topic=(chronic obstructive lung disease)
#4 #3 OR #2 OR #1
#5 Topic=(Exercise) OR Topic=(physical activity)
#6 #5 AND #4
#7 Topic=(barrier*) OR Topic=(facilitator*) OR Topic=(self-talk) OR Topic=(solution*) OR Topic=(reason*)
#8 Topic=(belief*) OR Topic=(attitude*) AND Topic=(health*)
#9 Topic=(psych*) OR Topic=(social*)
#10 Topic=(predictor*)
#11 #10 OR #8 OR #7
#12 #11 AND #9 AND #6

Data from the papers were charted in a series of stages, first the key information related to each paper was extracted (author, date, sample characteristics, study design, analysis and the barriers and facilitators). The barriers and facilitators identified were then classified according to which elements of the COM-B model (as in Porcheret & Main, 2011) they addressed (see Table 7). As the data comes from a wide variety of study designs, the terms used to describe the facilitators and barriers were not uniform. If different terms were used in papers to described a similar concept, these were grouped and a single barrier was reported e.g. fatigue, tiredness and being too tired would all be encapsulated by the barrier *fatigue*, and breathlessness, dyspnoea, and struggling to catch breath would all be encapsulated by the barrier *breathlessness*. A brief narrative synthesis according to the COM-B components was carried out. As the focus of this review was to identify barriers and facilitators of any physical activity in PwCOPD, there was no exclusion based on the way activity was measured.

4.1.2 Results

Twenty-seven eligible papers published between 1983 and 2011 were included. The papers reported qualitative, quantitative and case study data. The barriers and facilitators were reported as associated with seven physical activity related outcomes; general disease management, functional performance, performing activities of daily living, health status, exercise performance/capacity, daily physical activity and times when PwCOPD struggle to breathe.

Barriers

All 6 components of the COM-B model were represented. Barriers associated with physical capability were; breathlessness, fatigue, exercise capacity, exacerbations, and the presence of co-morbid conditions. PwCOPD's psychological capability could be negatively affected by their coping skills, depression, low mood, anxiety and fear. Both time and weather were identified as physical opportunity barriers, and embarrassment, stigma and loneliness were classified as social opportunity barriers. Barriers that would impact on PwCOPD's automatic motivation were related to emotional reactions, these included a lack of self-esteem/ self-efficacy and frustration. Finally, the barriers associated with reflective motivation were perceptions of both illness and health. There is overlap between the psychological capability and automatic motivation categories as both could incorporate emotional reactions. If someone with COPD becomes anxious when they think about physical activity, this could affect their automatic motivation, however this could also affect the person's psychological strength to engage in thoughts about physical activity and at this point it would also disrupt their psychological capability.

Facilitators

As with the barriers, facilitators associated with all 6 components of the COM-B were found. To facilitate physical capability pacing/ energy conservation, using breathing techniques, having lower perceived exertion and having better lung functioning were all identified as having a positive influence. Using coping strategies; increased acceptance of the illness (and of bad days), trying, establishing a routine, and having high levels of commitment all facilitated psychological capability. The use of a medication action plan and a dyspnoea management plan, having regular follow-ups with HCPs, good weather, and a dog to walk were all found to facilitate physical opportunities. Social opportunity was facilitated by taking part in a class with peers, social support, social contact, sharing experiences, collaborative self-management with HCPs, and getting reinforcement and understanding from others. Automatic motivation could be facilitated by increasing self-efficacy and positive affect and by seeking to relax. And finally reflective motivation could be facilitated by seeing improvements, seeking to improve one's physical condition (feeling accountable), by HCPs emphasising that breathlessness is not harmful, by having a negative attitude towards smoking, and by having the perception that bronchitis was a serious illness.

Table 7: Barriers and facilitators by COM-B model components

COM-B Component		Barriers	Facilitators
Capability	Physical	Breathlessness Severity of COPD Fatigue Exercise capacity Exacerbations Presence of co-morbid conditions	Pacing/ energy conservation Breathing techniques Lower perceived exertion Better lung functioning
	Psychological	Poor coping skills Depression Low mood Anxiety Fear	Coping strategies Acceptance of the illness (and of bad days) Trying Establishing a routine Having high levels of commitment
Opportunity	Physical	A lack of time Unsuitable[i] weather	Medication action plan Dyspnoea management plan Regular follow-ups with HCPs Suitable[i] weather A dog to walk
	Social	Embarrassment Stigma Loneliness	Taking part in a class with peers Social support Social contact Sharing experiences Collaborative self-management with HCPs Getting reinforcement and understanding from others
Motivation	Automatic	Lack of self-esteem/ self-efficacy Frustration	Presence of self-efficacy Positive affect Seeking to relax

Reflective	Perceptions of illness Perceptions of health	Seeing improvements Seeking to improve one's physical condition (feeling accountable) HCPs emphasising that breathlessness is not harmful A negative attitude towards smoking The perception that bronchitis is serious

Discussion

This scoping review aimed to provide an overview of the potential barriers and facilitators of both physical activity and exercise that PwCOPD experience. By finding what might be preventing the target behaviour (physical activity), step 3 in the 8-step design process for designing persuasive technologies is satisfied (Fogg, 2009c). A range of barriers and facilitators relating to capability (both physical and psychological), opportunity (both physical, and social) and motivation (both automatic and reflective) were found. Many of the barriers identified would be amenable to intervention, and those that are not (e.g. unsuitable weather) might be addressed by improving awareness and coping skills in PwCOPD (for example, see the technology designed by Cooper & O'Hara, 2010; Marno et al., 2010). This analysis indicates that while undertaking exercise or physical activity is a complex process for PwCOPD, the behaviours can be explained in the context of the COM-B model (Michie, van Stralen, et al., 2011), and that this model might provide a useful framework to identify what is preventing a behaviour. To the authors knowledge, this is the first time the COM-B model has been used to identify the barriers and facilitators that relate to a behaviour from extant literature.

The alternative approach would have been to design an interview, focus group or questionnaire study with questions designed to cover all the COM-B components. The strengths of coding extant literature are that it is data from a large number of people, in a range of settings, collected using a variety of methods. Furthermore, fewer resources are needed to derive benefit if previous literature is used. However, it is limited in that a range of outcomes were reported in the literature, and some barriers might pertain only to some of these, and some might pertain to all, but not yet have been measured or identified as such. Furthermore, unlike the taxonomies of BCTs used in Chapters 2 and 3, the descriptions of the COM-B model components have not been written specifically to enable coding. The research undertaken to refine the taxonomies and ensure the techniques are clearly described, and intervention descriptions can be reliably coded with them has not been undertaken for the COM-B components. This may have resulted in a more subjective classification. For example, symptoms such as breathlessness, and fatigue, have been described previously as both a physical and a psychological phenomenon. It was decided to classify these as physical barriers, as from the PwCOPD's perspective, if high levels of breathlessness are reported, that is their experience and it would be more likely to be seen by the PwCOPD as a physical capability barrier. Whether it's objectively 'true' or not, and the level of breathlessness was actually a physical barrier to carrying out activity would need to be ascertained by a HCP, before an intervention is designed; if it was a physical barrier, the level of activity would need to be reduced, and perhaps built up more slowly, whereas if it was a psychological barrier, a greater understanding of breathlessness and how to cope might be more appropriate. From these studies it is not possible to tell which of these is the case, hence classifying them according to the PwCOPD's perspective. While acknowledging the limitations of this approach, the purpose of this scoping review was to identify what might be stopping PwCOPD from being physically active, in order to gain a greater understanding of the target behaviour in this population. A number of candidate barriers were identified, as well as some facilitators

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ii. Information sheet and consent form

The University Of Sheffield.

Participant Information Sheet

Using the SMART2 to encourage and support walking in COPD patients

We would like to invite you to take part in our research study. Before you decide we would like you to understand why the research is being done and what it would involve for you.

One of our team will go through the information sheet with you and answer any questions you have. We suggest this should take about 10 minutes

Please talk to others about the study if you wish and ask us if there is anything that is not clear.

What is the purpose of the study?

Pulmonary rehabilitation courses are known to be effective in increasing people's fitness levels. However, some people find it difficult to carry on exercising when the course finishes. This research looks at whether a system we have designed helps people with COPD to continue to exercise. The system, called the SMART2 encourages you to set goals and monitor your walking, then provides you with feedback on how you are doing. It has been tested with people who have heart failure, and we're interested in seeing if it could help people with COPD.

The purpose of the study is to try and help people with COPD increase their physical activity, and to see what people think of the SMART2 system.

The SMART2 system consists of a:

Mobile device

Pedometer

This study forms part of a PhD project, and the findings will inform a larger research project that aims to design a more complete home based self-management system for people with COPD.

Why have I been invited?

You have been invited because you have completed a pulmonary rehabilitation course within the last six months and have a diagnosis of COPD (Chronic Obstructive Pulmonary Disease).

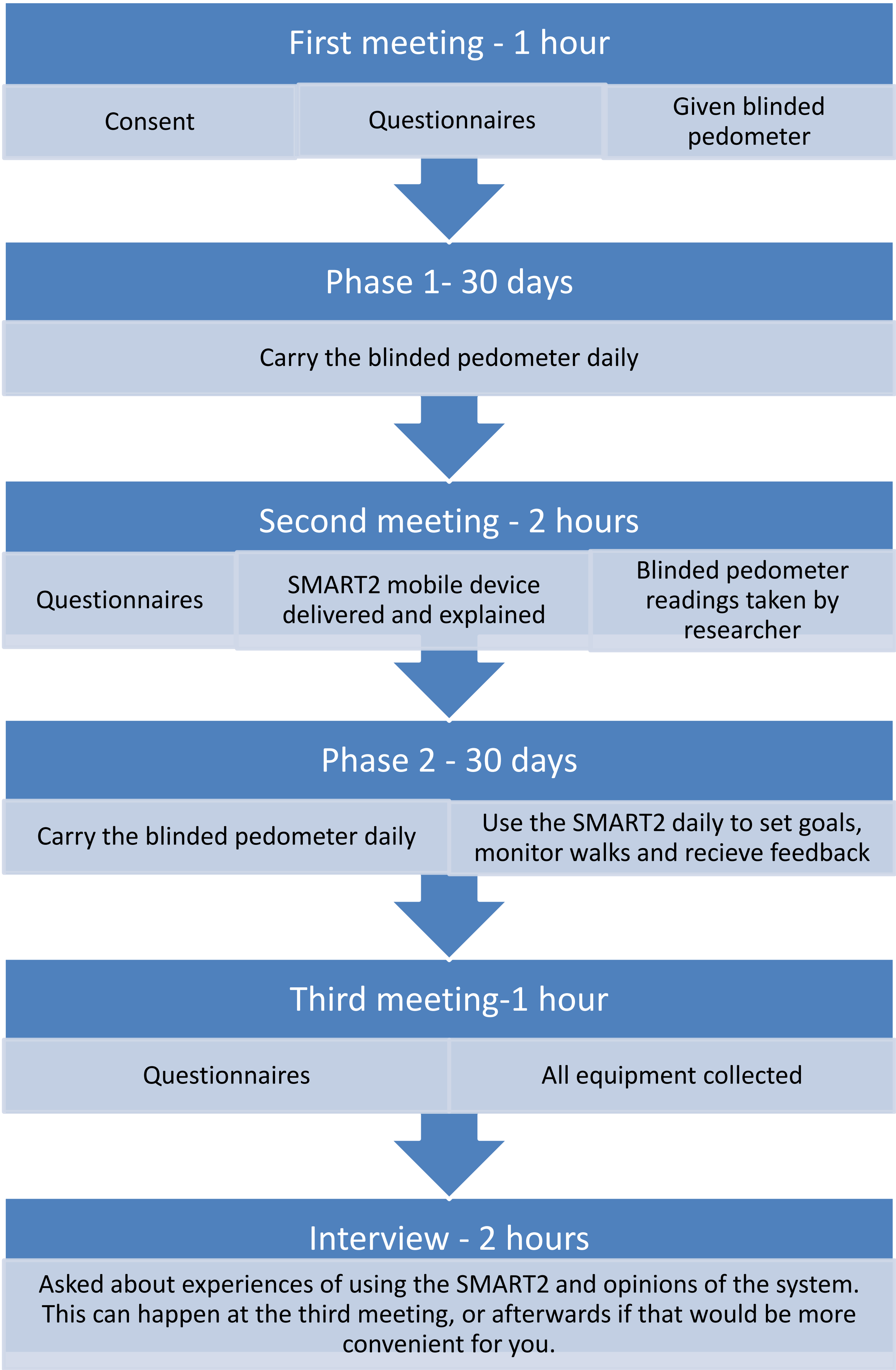
Do I have to take part?

This research is voluntary, you do not have to take part. If you do decide to take part you will be asked to sign a consent form. If, after this you want to stop taking part in the research, you can, and you do not have to give a reason. Whether or not you take part in this research will not affect the care you receive.

What will I have to do?

As outlined in the flowchart on the next page, if you agreed to take part in this research, you will be asked to:

- Sign a consent form
- Meet the researcher three or four times
- Complete three sets of questionnaires
- Carry a blinded pedometer for 60 days
- Set daily goals and look at feedback given from the SMART2 system for 30 days
- Complete an interview about your experiences that will be audio recorded.


First meeting - 1 hour
Consent
Questionnaires
Given blinded pedometer
Phase 1- 30 days
Carry the blinded pedometer daily
Second meeting - 2 hours
Questionnaires
SMART2 mobile device delivered and explained
Blinded pedometer readings taken by researcher
Phase 2 - 30 days
Carry the blinded pedometer daily
Use the SMART2 daily to set goals, monitor walks and recieve feedback
Third meeting-1 hour
Questionnaires
All equipment collected
Interview - 2 hours
Asked about experiences of using the SMART2 and opinions of the system. This can happen at the third meeting, or afterwards if that would be more convenient for you.

The first meeting (at a time and place that's convenient for you) will involve:

- The researcher answering any of your questions
- Signing a consent form
- Filling out questionnaires related to your current experiences of physical activity and technology
- Being given a blinded pedometer

A pedometer is a small piece of technology that counts the number of steps someone does. You will be asked to carry the pedometer for 60 days. It will have a covered screen to prevent you from seeing the number of steps, this makes it a 'blinded pedometer'.

After 30 days, at a time that is convenient for you, someone from the research team will visit your house and deliver the SMART2 mobile device. The equipment will be set up and you will be given instructions on how to use it. At this time you will be asked about your goals relating to physical activity, and an initial walking goal will be set. This will be something like 'walk for 5 minutes'. You will also be asked to complete the same questionnaires again, and the researcher will take the step counts from your blinded pedometer and give it back to you.

Any questions will be answered and you will be asked to try the equipment out for yourself before the researcher leaves. If there are any problems with the equipment, or you're not sure of anything, you will be able to contact the research team between 9am and 5pm during weekdays on 01142 222975.

For the next 30 days you will be asked to:

- Complete daily timed walks using the mobile device
- Have a look at the feedback given by the device about your progress.

Following this 30 day phase, someone from the research team will come and collect the equipment from you and arrange a time to do the interview. If it's convenient, this can be at the same time. The interview will take no more than two hours and will cover your experience of using the SMART2. There are no right or wrong answers and you will have the option not to answer any questions you don't want to. This interview will be audio recorded. You will be given the option to receive the summary findings of the study if you would like them.

Expenses and payment

Unfortunately we cannot pay you for taking part in this study, however if you choose to meet the researcher somewhere other than your home for the first meeting or the interview, reasonable travel costs will be refunded.

What are the possible disadvantages and risks of taking part?

The main inconvenience this research will cause is the daily monitoring. You will need to be willing to carry the pedometer with you for the whole 60 days, and to interact with the SMART2 system daily for 30 days.

What are the benefits of taking part?

We cannot promise that this study will have any effect on your level of activity or fitness. However, we hope that you will find the study enjoyable to take part in. The results of this study and the opinions that you give during the interview will inform the future development of a more comprehensive self-management technology for COPD patients. It is hoped that this system will help people with COPD to maintain the benefits gained during pulmonary rehabilitation as well as feel more confident and in control of their condition and their level of exercise.

What if there is a problem?

If you feel unwell at any time during the research you should contact your GP or Breathing Space staff on **01709 421700** as you have been advised to throughout the pulmonary rehabilitation course.

If there is a problem with the equipment we have supplied you can ring the researcher within office hours (9-5 Mon-Fri) on 01142 222 975

If you are unhappy about any aspect of the way the study has been conducted you can contact the educational supervisor for this project at m.hawley@sheffield.ac.uk

Will my taking part in this study remain confidential?

Your GP will be informed if you agree to participate in this study, they will not have access to any other information collected. All information we collect will be stored securely at the University and only used for the purposes of research. Information from questionnaires, interviews and the blinded pedometer will only be identified by a code, not your name. Paper copies will be held in a locked filing cabinet and electronic copies will be stored on a University computer protected by a password. Any information collected on a portable storage device (for example, an audio recorder) will be transferred to the computer as soon as possible and deleted from the portable device. Any identifiable information (for example, your name and contact details) will be stored separately from the above information in a locked filing cabinet and a password protected file on a University computer. The filing cabinets and computer used will be kept secure in a room only accessible to researchers at the University. After the project ends, information will be stored in a secure, locked university archive space for a further five years, this will be identified only by a participant number. No identifying information will be included in any publications or presentations about this research.

What will happen to the results of the research?

The results of this research will be published in academic journals, and presented at conferences. They will form part of a PhD thesis that will be published online. They will also be used to inform future research in both this research team and the wider community of researchers. No information that can identify you personally will be made available.

Who is organising and funding this research?

This research is being overseen by the University of Sheffield, they have provided insurance cover for any negligent harm arising from the management, design and/or conduct of this research for which they may be legally liable. The research is funded through a studentship from the Engineering and Physical Sciences Research Council.

Further information and contact details

Please feel free to discuss this research with friends, family members or your health professionals before deciding whether to participate.

If you have any questions, would like to discuss the research with one of the research team, or think you might like to take part please contact Kiera Bartlett at 01142 222975 or k.bartlett@sheffield.ac.uk

For further information about the SMART technology, and research that has already been completed with the system, please see: http://www.thesmartconsortium.org/Smart_2/index.php

You may also like to look at the helpful booklets about taking part in health research, which are produced by Involve. Involve is a national advisory Group, funded by the Department of Health, which aims to promote and support active public involvement in NHS, public health and social care research. They can be contacted at:

Involve, Wessex House, Upper Market Street, Eastleigh, Hampshire, SO50 9FD

Tel: 023 8065 1088.Email: admin@invo.org.uk.Website: www.invo.org.uk

Thank you for reading this information sheet, please feel free to take it with you.

Centre Number:
Study Number:
Patient Identification Number for this trial:

The University Of Sheffield.

CONSENT FORM

Title of Project: Using the SMART2 to encourage and support walking in COPD patients
Name of Researcher: Kiera Bartlett
Please **initial** boxes

1. I confirm that I have read and understand the information sheet dated 15/04/2013 (version 3.0) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. __ __

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. __ __

3. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. __ __

4. I agree for the data collected from me to be used in future research __ __

5. I agree to being recorded during the interview, for this audio file to be transcribed verbatim (no identifying names will appear in the transcript and the file will only be identified with a participant number). I understand that if quotations from the interview are used, they will be anonymised __ __

6. I agree to my use of the mobile device being recorded and analysed.

7. I agree to my GP being informed of my participation

8. I agree to take part in the above study.

________________________	___________	_________________________
Name of participant	Date	Signature
________________________	___________	_________________________
Name of person taking consent	Date	Signature

iii. Approval letters

NHS ethics approval

NHS
Health Research Authority

NRES Committee South Central - Oxford A

Bristol Research Ethics Committee Centre
Whitefriars
Level 3 Block B
Lewins Mead
Bristol
BS1 2NT

Tel: 0117 342 1331
Fax: 0117 342 0445

18 April 2013

Miss Y Kiera Bartlett
School of Health and Related Research, University of Sheffield
Regent Court, 30 Regent Street
Sheffield
S14DA

Dear Miss Bartlett

Study title:	**Evaluating the efficacy of self-regulatory behaviour change techniques delivered through the Self Management supported by Assistive, Rehabilitation and Telecare Technologies (SMART) system in increasing walking behaviour in Chronic Obstructive Pulmonary Disease (COPD) patients: A series of N-of-1 studies**
REC reference:	**12/SC/0440**
Protocol number:	**130868**
Amendment number:	**Minor Amendment 1**
Amendment date:	**15 April 2013**
IRAS project ID:	**107368**

Thank you for your letter of 15 April 2013, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Information Letter for GP	2.0	15 April 2013
Interview Schedules/Topic Guides	2.0	15 April 2013
Participant Consent Form	2.0	15 April 2013
Participant Information Sheet	3.0	15 April 2013

Protocol	2.0	15 April 2013
Notification of a Minor Amendment		15 April 2013
Covering Letter		15 April 2013

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

12/SC/0440:	**Please quote this number on all correspondence**

Yours sincerely

T. Fairman

Mr Thomas Fairman
Committee Co-ordinator

E-mail: nrescommittee.southcentral-oxforda@nhs.net

Copy to: *Dr Sally Atkinson, Rotherham NHS Foundation Trust*
Nicola Donkin, University of Sheffield

The Rotherham NHS
NHS Foundation Trust

Rotherham Hospital
Moorgate Road
Oakwood
Rotherham
S60 2UD

Telephone 01709 820000
www.therotherhamft.nhs.uk

R&D Reference: ***Project No 12-07-01*** **(please quote this number on all correspondence)**

Miss Y Kiera Bartlett
School of Health and Related Research,
University of Sheffield
Regent Court,
30 Regent Street
Sheffield
S1 4DA

19th April 2013

Dear Miss Bartlett,

Re: Using the SMART2 to encourage and support walking in COPD patients V1.

Sponsor: **The University of Sheffield**

Funder: **Engineering and Physical Sciences Research Council.**

Minor Amendment dated 15/04/2013

The following documents have been submitted:-

Document	Version	Date
Research Protocol	2	15/04/2013
Participant Information Sheet	3	15/04/2013
Consent Form	2	15/04/2013
Semi Structured Exit Interview Schedule	2	15/04/2013
GP Letter	2	15/04/2013
Minor Amendment Oxford REC Approval by email		12/04/2013

These have been reviewed by the Research Office who have no objections to the amendments.

Please ensure a copy of this letter is filed in the Investigator Site File.

Yours sincerely

R. Athorn

Rachel Athorn
Research Management & Development Facilitator
Rachel.athorn@rothgen.nhs.uk

Rotherham Research Alliance
Research & Development, DLE91, D Level, PGME corridor

Leads in Research & Development Miss D Patel & Jo Abbott
Research & Development Manager Dr Sally Atkinson Direct Line 01709 427656/4177 Email sally.atkinson2@rothgen.nhs.uk
In partnership with NHS Rotherham and Rotherham Community Health Services

POSITIVE ABOUT DISABLED PEOPLE

c.c. Professor Mark Hawley , ScHARR, University of Sheffield, Regent Court, 30 Regent Street, Sheffield, S1 4DA (email: mark.hawley@sheffield.ac.uk)

c.c. Professor Paschal Sheeran, Department of Psychology, The University of Sheffield, Sheffield, S10 2TP (email: P.Sheeran@sheffield.ac.uk)

Rotherham Research Alliance
Research & Development, DLE91, D Level, PGME corridor

Leads in Research & Development Miss D Patel & Jo Abbott
Research & Development Manager Dr Sally Atkinson Direct Line 01709 427656/4177 Email sally.atkinson2@rothgen.nhs.uk
In partnership with NHS Rotherham and Rotherham Community Health Services

POSITIVE ABOUT DISABLED PEOPLE

iv. Exit interview topic guide

This interview schedule is semi-structured so the exact content will be determined by the participant's experiences and views.

Introduction:

INTERVIEWER: Thank you so much for taking part in this research, your time and effort is greatly appreciated. The final part of the research is this interview. I am interested in your thoughts and opinions about the research you've just completed and physical activity more generally. There are no right or wrong answers, so please answer honestly, any information about your experiences, positive or negative is interesting to us.

If there are any questions you don't want to answer, just let me know and we can skip them, you don't have to give a reason. If you want to stop the interview, or take a break from the interview and come back to it, just let me know.

I'd like to record this interview if possible, so I can concentrate on what you're saying instead of scribbling down notes, is that alright?

(If participant agrees, the recording will be started at this point).

INTERVIEWER: So, you've been taking part in this research for about two months now, I'm interested in your experiences over this time, how you've found it, and what you think about it.

Thinking about the first 30 day period compared to the second, was there anything that might have changed your average daily routine?

Prompts: Illnesses? Used the car more, or less? Went on holiday? Had visitors etc?

<u>Section one: Physical activity</u>

I'd like to talk to you a little bit about your level of physical activity, what kind of activities do you do at the moment? Are you doing the amount you'd want to? What stops you doing more? What helps you to do what you do?

Could you tell me if you use oxygen at all, and if so, how long for in a typical day, or to do what activities.

Section two: Experiences of using the blinded pedometer

How did you find wearing the blinded pedometer? How did you feel about wearing it? Did anyone else comment on it?

Did you feel the amount of walking you did changed when you were wearing the blinded pedometer?

Were there any days/ occasions you didn't wear the pedometer?

- If applicable interviewer could explore the reasons, and activity the participant didn't want to wear it for etc.

Section three: Experiences of using the mobile device:

How did you find using the device? Easy/ difficult?

Did anyone else comment on it?

Describe your typical use of the device?

Probes if any aspects have not been covered:

How did you find goal setting? Probe how goals were decided upon and why.

How did you find the self-monitoring while you were walking? Probe whether the screen was looked at during the walk. Was the information enough/ of interest etc.

How did you decide how to rate your walk? Talk me through a typical decision process.

How did you find the graph? Probe whether it was looked at, why, what information was looked at. Was it clear?

Were there any days when you didn't use the device?

- Again, the interviewer will explore why if applicable.

Did you feel the amount of walking you did changed when you were using the device?

- Interviewer will explore why participant's feel their level of walking either changed or remained the same. Explore possible links to any particular components for example, or is it to do with following guidelines and instructions they have been given.

Did you enjoy using it?

Was there anything you particularly liked or disliked about the device?

If you had the chance to keep the system, and no-one was monitoring your use of the device do you think you would carry on using it?

- Why/ why not? Explore participant's level of confidence in their ability to self-manage walking behaviour. Explore whether the system is seen as persuasive or motivating.

Do you think you'd recommend the system to a friend with COPD?

- Why/ why not?

<u>Section four: Overall experiences and suggestions</u>

Do you think technology like this can help increase physical activity for people with COPD?

- Why/ why not?

Were there any situations you found it hard to complete the exercise in?

- Why/ what happened?

Is there anything you think could be added, taken out, or improved?

- Refer back to the above barriers for any suggestions about how these could be addressed

Is there anything you'd like to add about the research, or using technology to encourage physical activity?

v. Demographic questionnaire

The University Of Sheffield.

Demographic Questionnaire

We would like to collect some information about you, this will help us describe who has taken part in the research. Please complete the below details:

1. Age ______________________________
2. Gender Male ☐ Female ☐
3. Postcode _______________________
4. Time since diagnosis with COPD ________ years and _________months
5. Date pulmonary rehabilitation course was completed - _________________
6. Number of times you have completed a pulmonary rehabilitation course _________

Please turn this sheet over to complete the rest of the questions.

We would like to know about your current level of technology use, please read the list of devices and for each tick how frequently you use them:

Device	Every day	Once a week	Less than once a week	Never
Mobile Phone	☐	☐	☐	☐
Computer (laptop or desktop)	☐	☐	☐	☐
Tablet computer (such as an i-pad)	☐	☐	☐	☐
Television	☐	☐	☐	☐
Radio	☐	☐	☐	☐
Satellite Navigation (Sat Nav)	☐	☐	☐	☐
MP3 Player	☐	☐	☐	☐
Camcorder	☐	☐	☐	☐
Digital Camera	☐	☐	☐	☐
Other device (please state) ______________________ ______________________	☐	☐	☐	☐

Which of the following statements best describes your current condition?

Not troubled by breathlessness except on strenuous exercise	☐
Short of breath when hurrying on the level or walking up a slight hill	☐
Walk slower than people of the same age on level ground because of breathlessness, or have to stop for breath after about 15 minutes when walking at own pace on level ground	☐
Stop for breath after walking about 100 yards or after a few minutes on level ground	☐
Too breathless to leave the house, or breathless when dressing or undressing	☐

5 Appendix III: For Chapters 6 & 7

This appendix shows additional tables and research materials relating to Chapter 5

i. The survey containing all the scenarios and feedback screens
ii. Interview guides for all stakeholders
iii. Overview and features of the top five apps targeting physical activity
iv. Ethical approvals
v. Information sheets and consent forms for the survey study, online and paper
vi. Flow of Participants through the survey
vii. Integration matrix

i. Survey containing all the scenarios and feedback screens

NB: Some of the formatting of the survey has been changed to fit with the necessary margins of this thesis. The font size in the answer grids has been reduced in some cases and the pagination altered.

Opinions of Persuasive Technology for Increasing Physical Activity Survey

Thank you for agreeing to complete this survey.

Please ensure you have read and understood the Information Sheet provided, and completed and signed the Consent Form.

If you have any questions before beginning the survey, while completing it, or afterwards, please get in touch with Kiera Bartlett on 01142 222975 (further contact details provided on the information sheet).

The Survey is split into four sections; Questions About You; Questions About Physical Activity; Questions About Technology and Questions about the Scenarios. Please complete every section.

There are instructions written in **bold** text to help you in completing the survey. For example, in some cases answering 'Yes' to a question will mean you should answer different questions to someone who answers 'No'. Please read these instructions carefully, as you will not need to answer every question.

There are no right or wrong answers, please answer honestly. We are just interested in your opinion. If there are any questions you would prefer not to answer, please leave them blank.

You do not need to complete all five sections at once, please feel free to stop and start as often as you'd like. Completed surveys should be returned by 31st June 2013.

Section 1: Questions About You

Question 1: Gender (tick as appropriate) Male ☐ Female ☐

Question 2: Age in years ______

Question 3: Postcode ________

Question 4: How long have you been diagnosed with COPD? _____years ______months

Which of the following statements best describes your current condition?

Not troubled by breathlessness except on strenuous exercise	☐
Short of breath when hurrying on the level or walking up a slight hill	☐
Walk slower than people of the same age on level ground because of breathlessness, or have to stop for breath after about 15 minutes when walking at own pace on level ground	☐
Stop for breath after walking about 100 yards or after a few minutes on level ground	☐
Too breathless to leave the house, or breathless when dressing or undressing	☐

Section 2: Questions About Physical Activity

When we say physical activity, we mean any type of movement. This can include exercise such as going to the gym or swimming as well as everyday activity such as walking in and around the house or doing housework or gardening.

Light-intensity activity means you're working hard enough to raise your heart rate slightly, you could still talk or sing the words to a song while performing this level of activity

Question 5: On average how many days per week do you perform **light** intensity activity?

_______________ days per week

Question 6: On average, how many minutes per week do you spend performing **light** intensity activity?

_______________ hours and_______________ minutes per week

Moderate-intensity aerobic activity means you're working hard enough to raise your heart rate and break a sweat. One way to tell if you're working at a moderate intensity is if you can still talk but you can't sing the words to a song.

Question 7: On average how many days per week do you perform **moderate** intensity activity?

_______________ days per week

Question 8: On average, how many minutes per week do you spend performing **moderate** intensity activity?

______________ hours and ____________minutes per week

Vigorous-intensity aerobic activity means you're breathing hard and fast, and your heart rate has gone up quite a bit. If you're working at this level, you won't be able to say more than a few words without pausing for a breath.

Question 9: On average how many days per week do you perform **vigorous** intensity activity?

_______________ days per week

Question 10: On average, how many minutes per week do you spend performing **vigorous** intensity activity?

_______________ hours and ____________minutes per week

Question 11: Have you ever been advised by a health professional to increase your physical activity?

Yes ☐ No ☐ I don't know ☐

Question 12: How do you feel about your level of physical activity?

a) I would like to do more ☐

b) I would like to keep it the same ☐

c) I would like to do less ☐

If a) to Question 12: What do you think currently stops you doing more physical activity?

Tick any of the below statements that apply:

I get breathless	☐	I don't feel in the mood	☐
I get anxious or worried	☐	I feel tired	☐
I get frustrated	☐	A condition or illness aside from COPD stops me	☐
I get embarrassed	☐	I haven't the time	☐
The weather stops me	☐	I'm recovering from an exacerbation (flare up)	☐
I have no place to exercise	☐	A health care professional (Dr/ nurse/ physiotherapist) has advised me not to	☐
Other	☐		

If ‘other’ please specify

If b) to Question 12: Why do you want to keep your level of physical activity the same?

I already do as much physical activity as I can manage ☐

I am happy with the level of physical activity I do ☐

If c) to Question 12: Why do you want to do less physical activity?

Tick any of the below statements that apply:

I get breathless	☐	I don’t feel in the mood	☐
I get anxious or worried	☐	I feel tired	☐
I get frustrated	☐	A condition or illness aside from COPD limits what I can do	☐
I get embarrassed	☐	I haven’t the time for other things	☐
The weather	☐	I’m recovering from an exacerbation (flare up)	☐
I have no place to exercise	☐	A health care professional (Dr/ nurse/ physiotherapist) has advised me to	☐
Other	☐		

If ‘Other’ please specify

Question 13: Have you been offered a course of Pulmonary rehabilitation?

Yes ☐ No ☐ I don’t know ☐

If No or I don't know to Question 13: Please go to **Question 14**.

If Yes to Question 13:

Have you completed a course in pulmonary rehabilitation? (circle as appropriate)

a) Yes
b) No
c) Currently completing
d) Attended some sessions but stopped

If b) or c): Please continue to **Question 14.**

If a) When did you complete the course? (DD/MM/YY)

____/_____/________

How many times have you completed the course? _________

If d) how many sessions did you attend? _____________

Why did you stop?

____

____

____

____

____

Section 3: Questions About Technology

Question 14: Do you currently use a computer? This includes use of a desktop computer with a keyboard and mouse, a laptop or a tablet touchscreen computer such as the i-pad.

Yes ☐ No ☐

If No to Question 14: Please go to **Question 15**.

If Yes to Question 14: How often do you use a computer?

Multiple times a day	☐	Less than once a week but several times per month	☐
Once a day	☐	Once a month	☐
Less than once a day, but several times per week	☐	Less than once a month.	☐
Once a week	☐		

What do you use the computer for (tick all that apply):

Email	☐	Getting contact information (including maps and directions)	☐
Social networking (i.e. Facebook or Twitter)	☐	Comparing prices or services	☐
Reading the news	☐	Watching TV programmes or films	☐
Getting health related information	☐	Listening to the radio	☐
Reading blogs	☐	Playing games	☐
Shopping	☐	Video calling (i.e. Skype)	☐
Using online support groups	☐	Other	☐

If 'Other' please specify:

____

____

____

Question 15: Do you currently use a mobile phone?

Yes ☐ No ☐

If No to Question 15: Please skip to **Question 16**.

If Yes to Question 15: How often do you use a mobile phone?

Multiple times a day	☐	Less than once a week but several times per month	☐
Once a day	☐	Once a month	☐
Less than once a day, but several times per week	☐	Less than once a month.	☐
Once a week	☐		

Can your phone connect to the internet?

Yes, and I use the internet on my phone	☐
Yes, but I don't use the internet on my phone	☐
No, my phone doesn't connect to the internet	☐
I'm not sure	☐

What do you currently use your mobile phone for? (tick all that apply)

Calling	☐
Texting	☐
Using the internet	☐
Using applications ‘apps’ I have downloaded	☐
Other	☐

Please specify:

____

____

____

____

Question 16: Have you **heard of or seen** any technology (i.e. on the computer, on the internet, or mobile phones) that is designed to try and help change people’s behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

Yes ☐ No ☐ Don’t Know ☐

If No or Don’t Know to Question 16: Please skip to **Question 19**

If Yes to Question 16: Please give details of the technology you’ve heard about:

____

____

____

____

____

Question 17: Have you ever **used** any technology (i.e. on the computer, on the internet, or mobile phones) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

Yes ☐ No ☐ Don't Know ☐

If No or Don't Know to Question 17: Please skip to **Question 19**

If Yes to Question 17: Please give details of the technology you've used to help change behaviour:

____

____

____

____

Question 18: Do you **still use** any technology (i.e. on the computer, on the internet, or mobile phones) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

Yes ☐ No ☐ Don't Know ☐

If Don't Know to Question 18: Please skip to **Question 19**

If Yes to Question 18:

How long have you been using it? (please give a number of weeks)

____

Please continue to Question 19

If No to Question 18:

How long did you use it for before you stopped ___________in weeks

Why did you stop?

____

____

Question 19: Would you **consider** using technology (i.e. on the computer, on the internet, or mobile phones) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking if you wanted to change your behaviour in the future?

Yes ☐ No ☐

Please describe why you would either consider using or not consider using such technology?

____

____

____

____

____

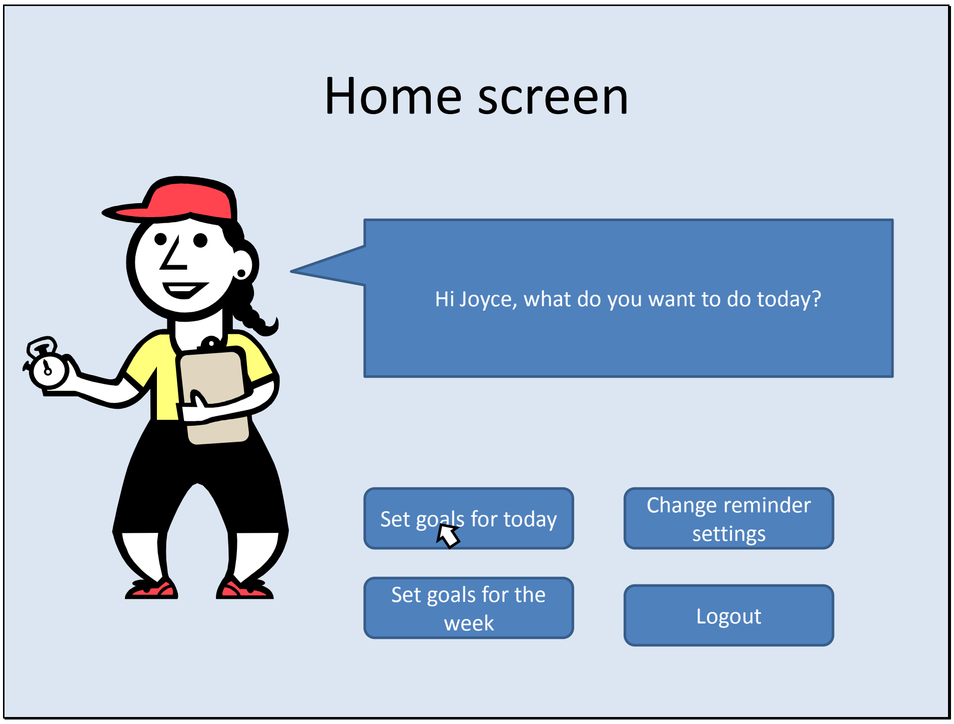
Section 4: Questions About the Scenarios

For this final section, you will be shown three ‘scenarios’. These describe examples of how technology might be used to encourage and support increases in physical activity for people with COPD. On the following pages there will be pictures of what the screens might look like and descriptions of how to use the technology. After each there are some questions to answer.

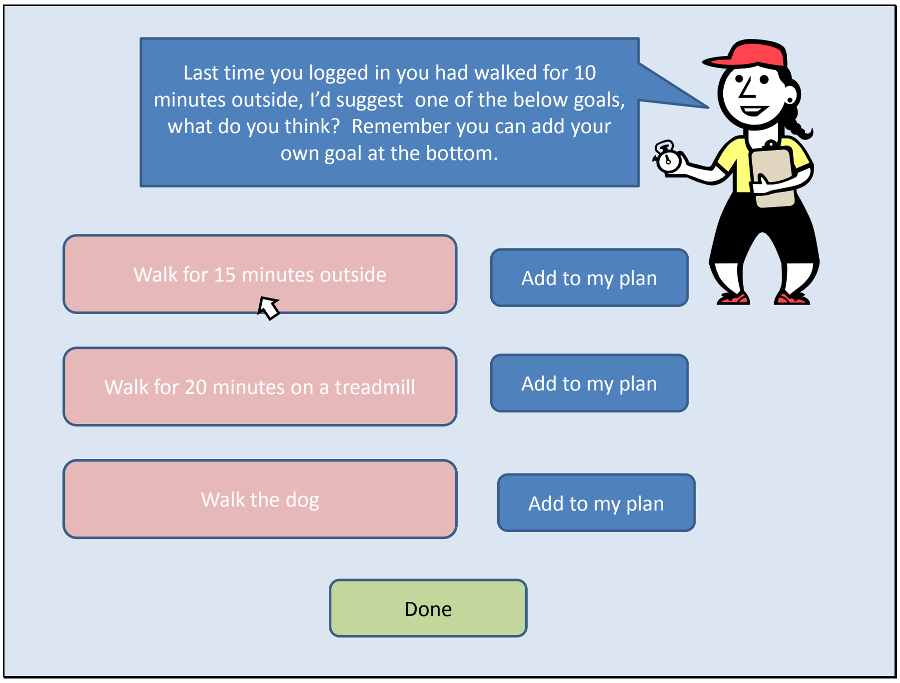
These are not systems that have been developed, so please be honest in your opinion.

Scenario 1

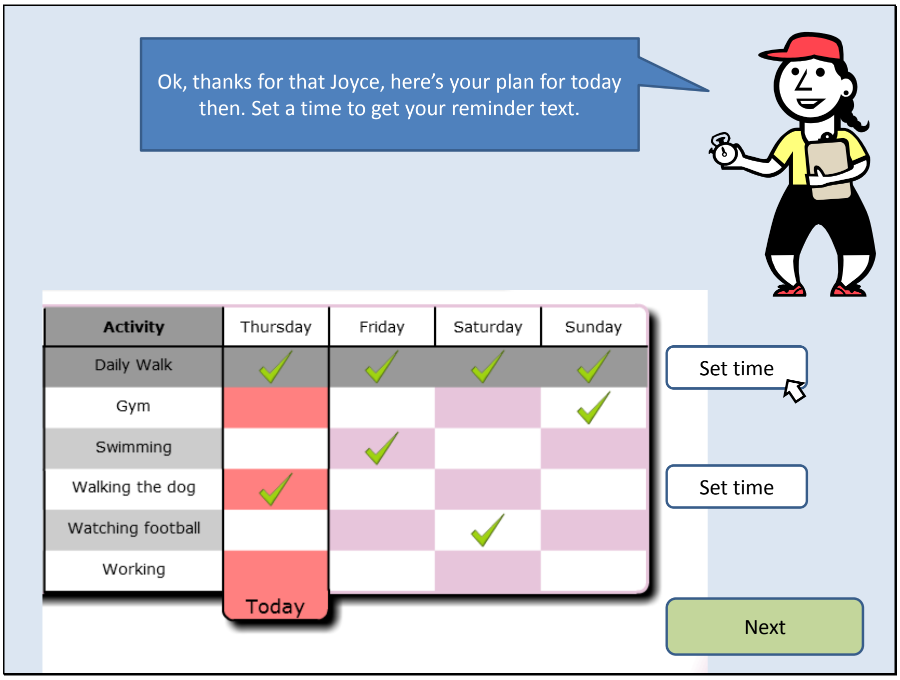
Joyce has noticed that she can’t do the activities she used to as she gets breathless. Her Dr has advised her to increase her physical activity to 30 minutes per day. She has decided to use a new system to help her increase her walking. It uses a computer and a mobile phone



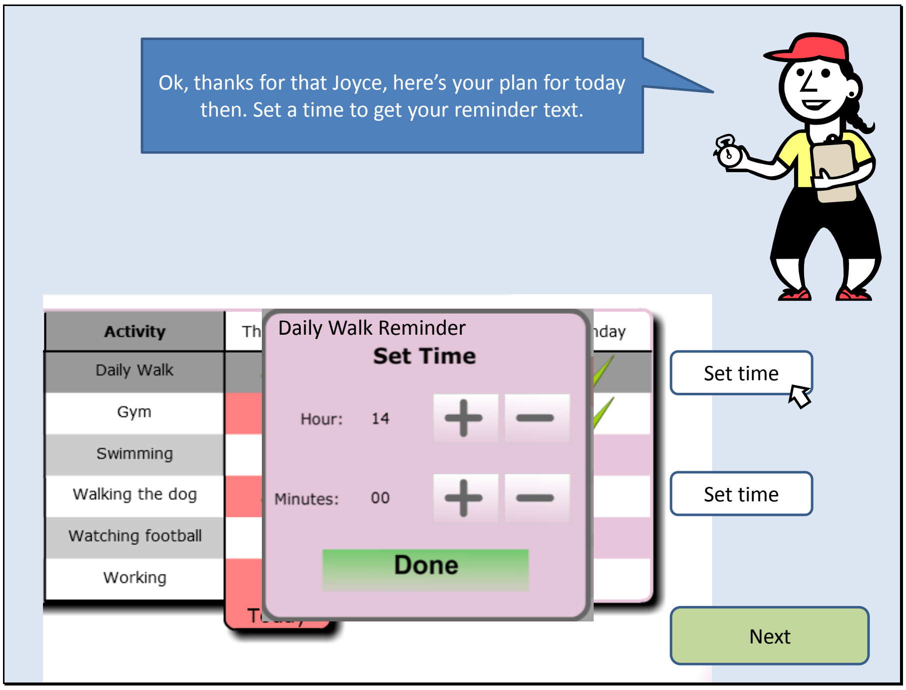
Joyce opens the system on her home computer, her ‘coach’ greets her and asks what she would like to do. The information Joyce puts in is only seen by herself and the system, no real-life coach would see the information. Joyce selects set goals for today.



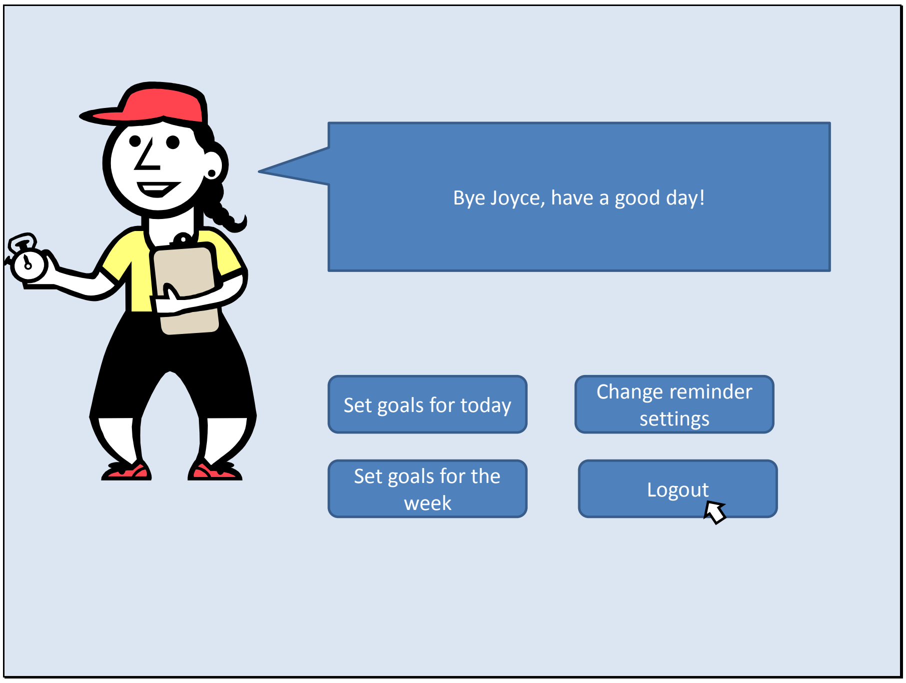
Her coach gives her a summary of what she did last time and suggests some goals. Joyce can choose from the suggested goals, or add her own. She chooses to aim to walk for 15 minutes outside and to walk the dog.



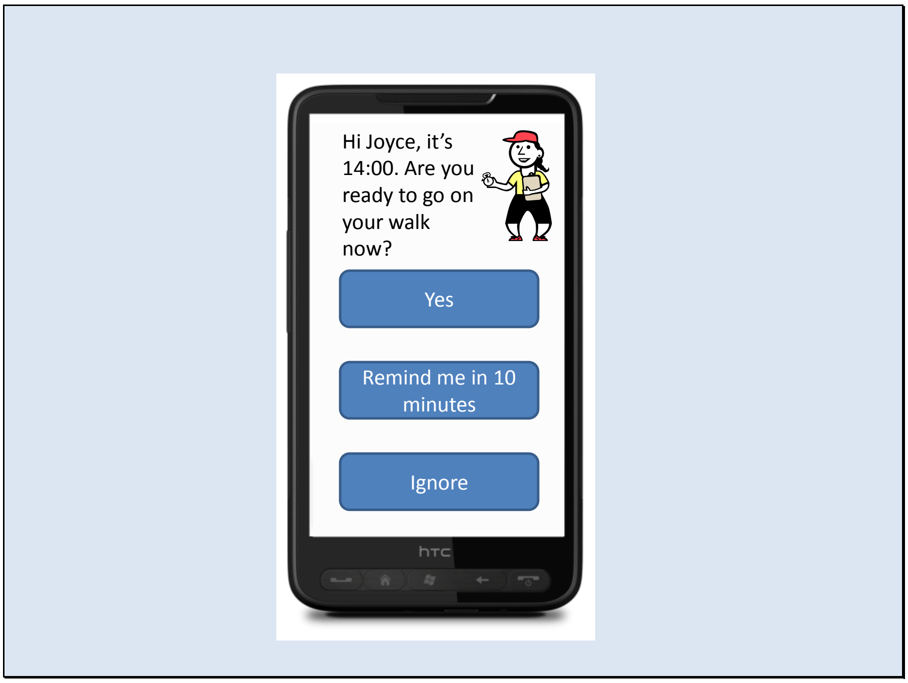
Her coach thanks her and adds the goal to her daily plan. The coach asks her to set a time for a reminder text.



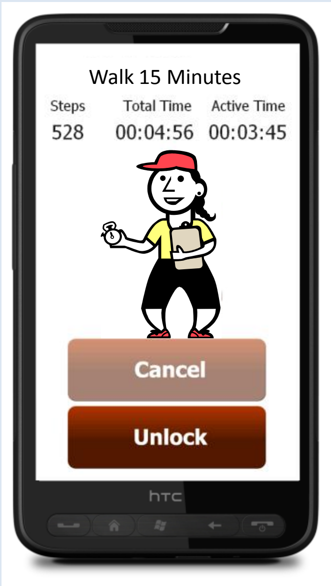
Joyce sets 2 o'clock as the time she would like to receive her reminder text.



Joyce switches off the computer, and continues her day.



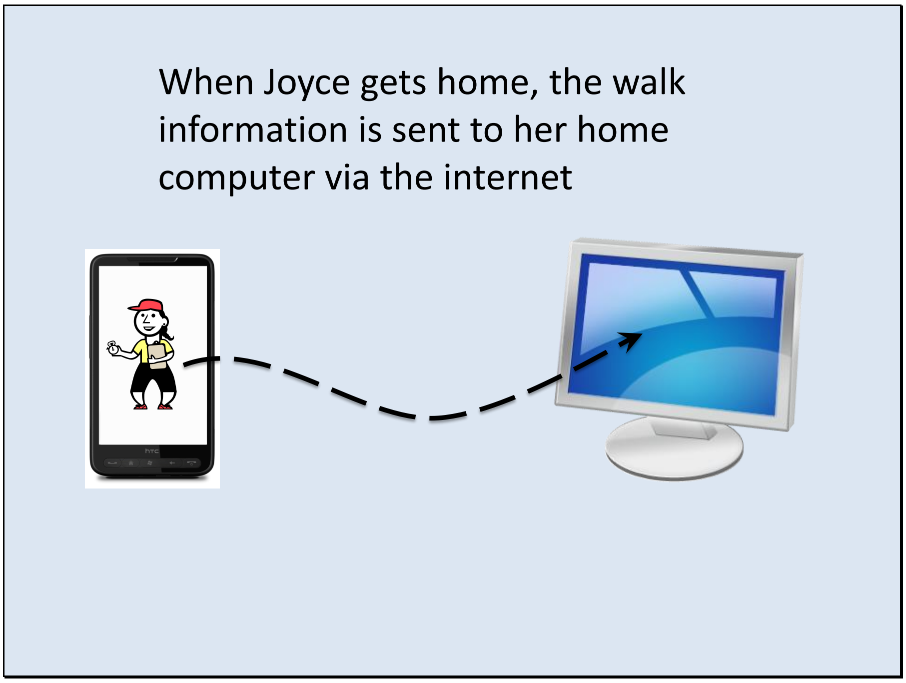
At 2 o clock Joyce receives a reminder text from her coach, and begins her walk

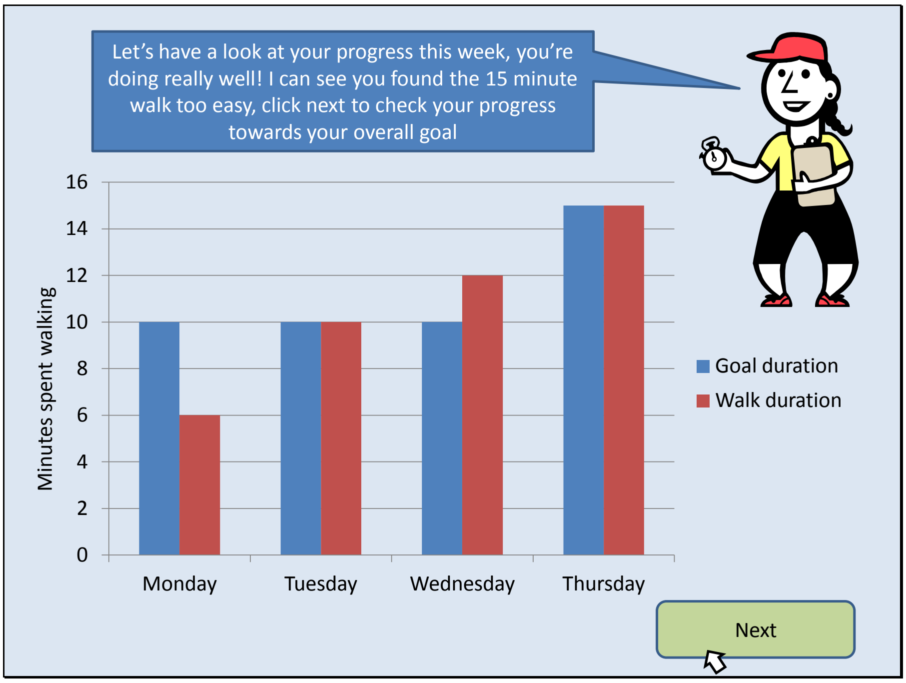


Joyce has headphones for her phone, as she walks she can hear messages from her ‘coach’ encouraging her and letting her know how long she’s been walking and how long she has left

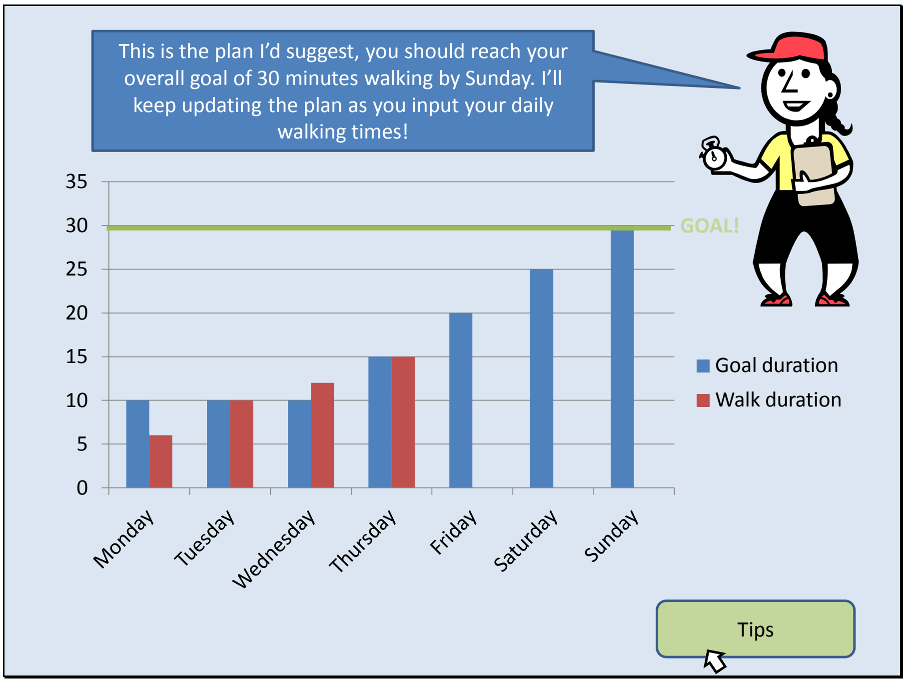
Joyce completes her walk

Following the walk the coach congratulates Joyce and encourages her to rate her walk. This allows the system to make suggestions for future goals.

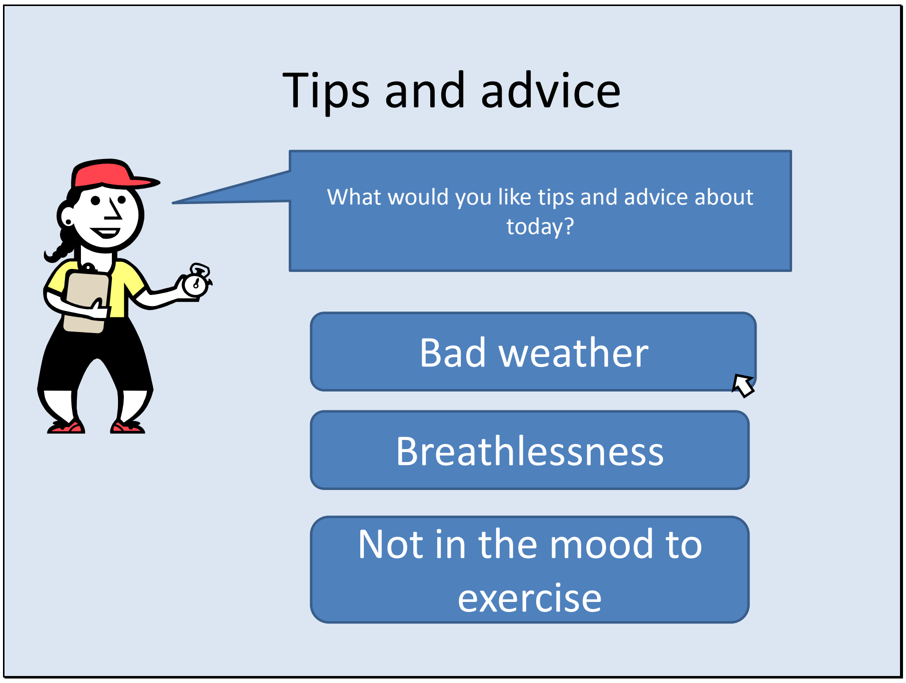




The next time Joyce turns on her computer, the coach provides a summary of her activity.



The coach outlines the plan she wants Joyce to follow. She can see her future suggested goals and when she's likely to fulfil her goal. Joyce can also look at tips suggested daily.



Joyce can choose from a list of commonly experienced problems when trying to complete physical activity, and get tips and advice from her coach on how to deal with them.

Please turn over to answer the questions

Imagine you could use this system. Please indicate how much you agree with each of the following statements by ticking the appropriate box. There are no right or wrong answers, we are just interested in your opinion.

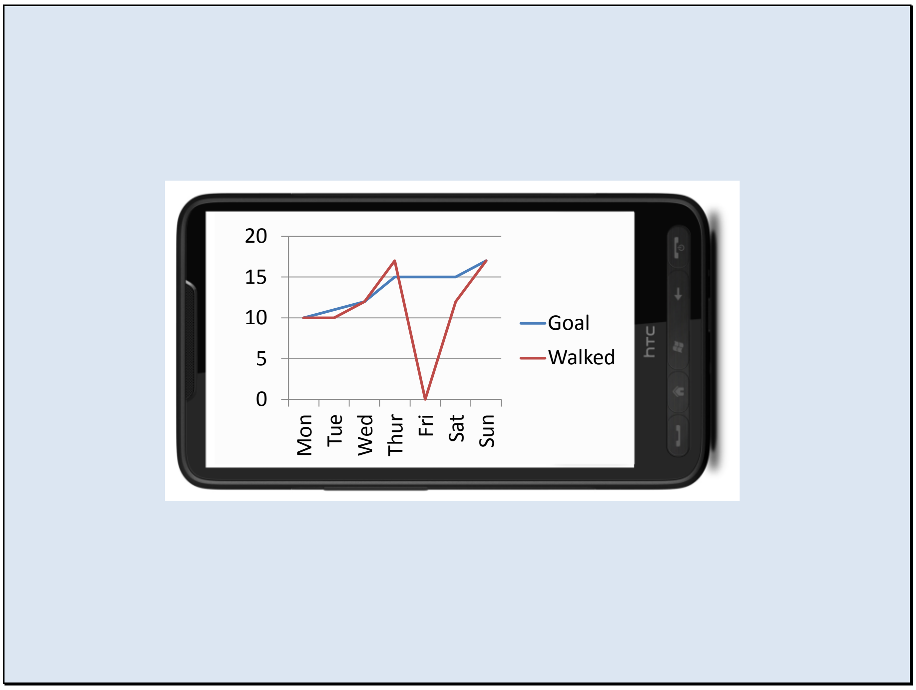
Scenario 1 ….	Strongly Agree	Agree	Slightly Agree	Neutral	Slightly Disagree	Disagree	Strongly Disagree
is interesting.							
would have influence on me.							
is personally relevant to me.							
makes me think about my physical activity							

	Strongly Agree	Agree	Slightly Agree	Neutral	Slightly Disagree	Disagree	Strongly Disagree
I would not enjoy using this system							
I think this system would be useful in increasing my physical activity							
If I wanted to increase my activity levels I would not use this system							
This system makes me want to increase my physical activity							
Other comments:							

When Joyce is out and about she can see how she has been doing for the last week on her mobile phone.

The next 5 screens show different ways of showing the same information, have a look through them and answer the questions for each.

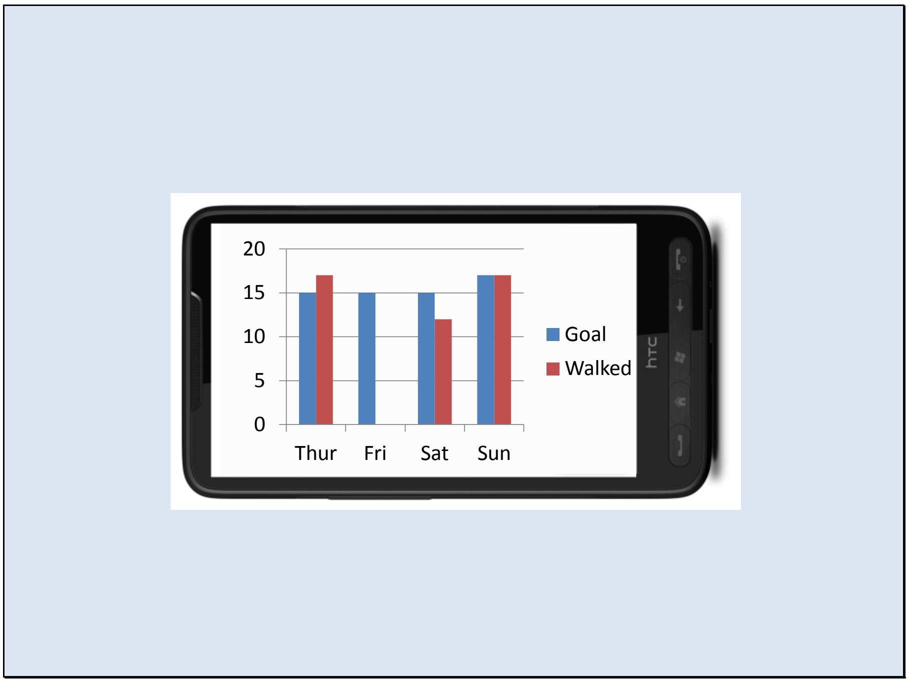
1.



Here you can see she reached her goal on Monday, Wednesday and Sunday, nearly met it on Tuesday and Saturday, walked more than her recommended goal on Thursday and did no walking at all on Friday.

Screen 1	**Strongly Agree**	**Agree**	**Slightly Agree**	**Neutral**	**Slightly Disagree**	**Disagree**	**Strongly Disagree**
Is attractive							
Is confusing							
Would not be useful							
Is easy to understand							

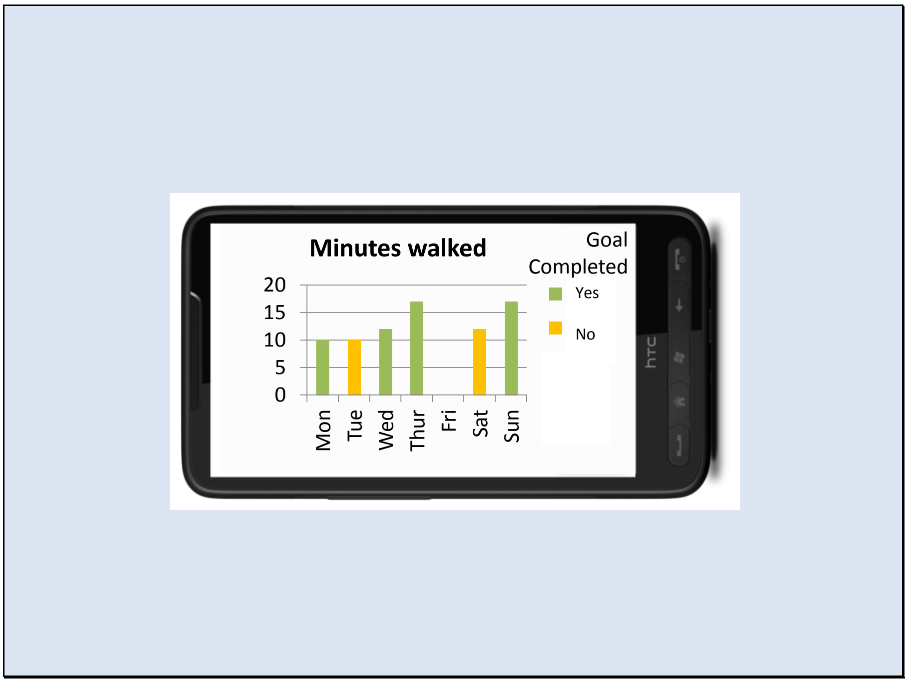
2.



Here is the same information as a bar chart, due to the size of the screen only the last 4 days are displayed.

Screen 2	**Strongly Agree**	**Agree**	**Slightly Agree**	**Neutral**	**Slightly Disagree**	**Disagree**	**Strongly Disagree**
Is attractive							
Is confusing							
Would not be useful							
Is easy to understand							

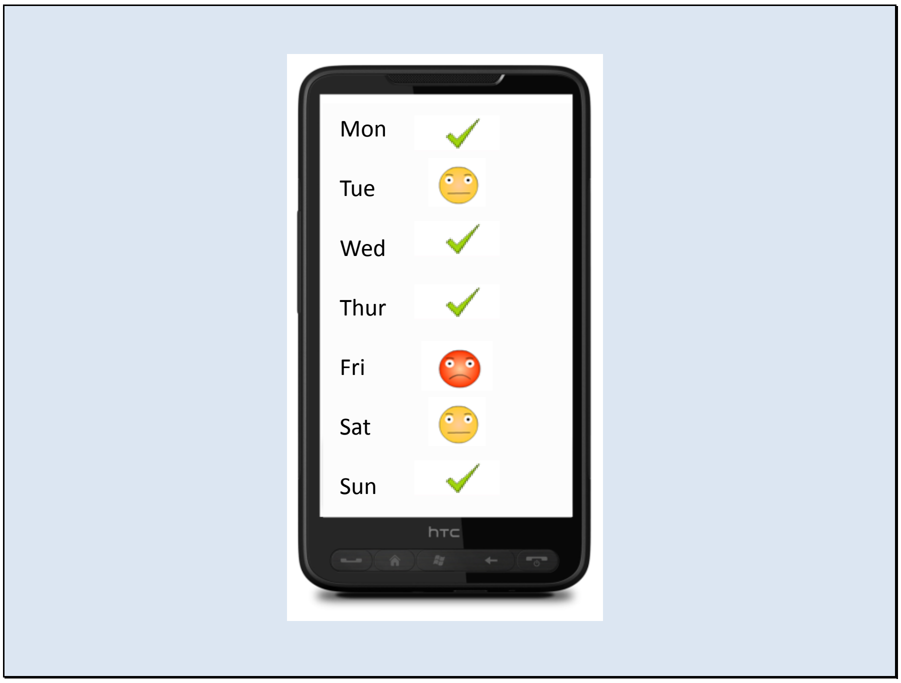
3.



This display doesn’t show what the goal was. Just how many minutes were walked. The colour of the bar indicates whether the goal was reached or not, green for yes, yellow for no.

Screen 3	**Strongly Agree**	**Agree**	**Slightly Agree**	**Neutral**	**Slightly Disagree**	**Disagree**	**Strongly Disagree**
Is attractive							
Is confusing							
Would not be useful							
Is easy to understand							

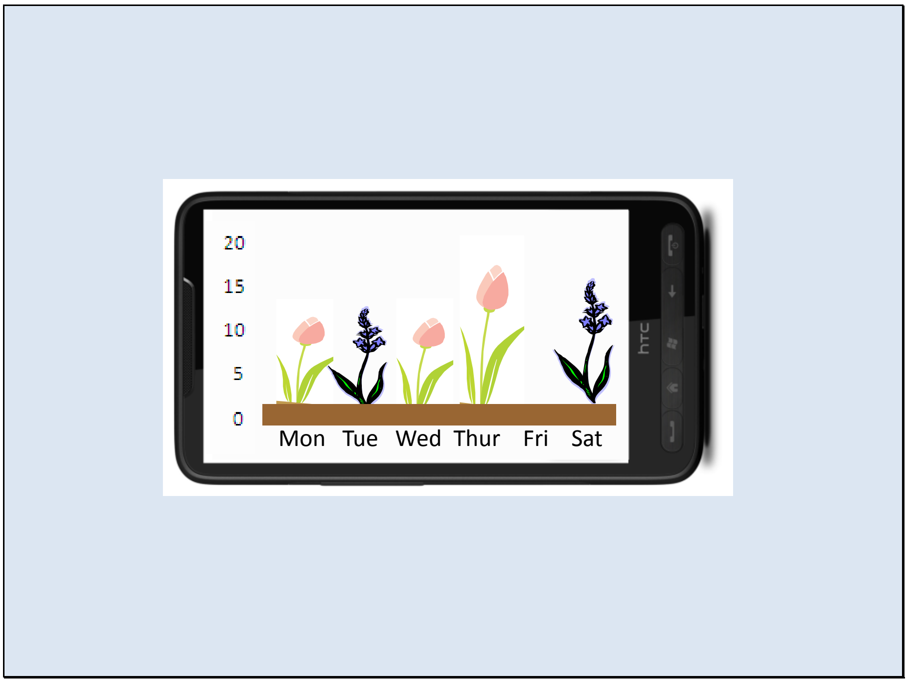
4.



This display gives a simple indication of whether the goal was completed (green tick); attempted but not completed (yellow face) or not attempted (red face).

Screen 4	**Strongly Agree**	**Agree**	**Slightly Agree**	**Neutral**	**Slightly Disagree**	**Disagree**	**Strongly Disagree**
Is attractive							
Is confusing							
Would not be useful							
Is easy to understand							

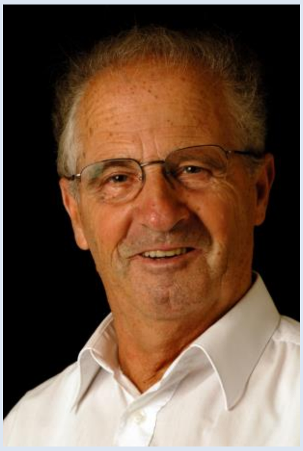
5.



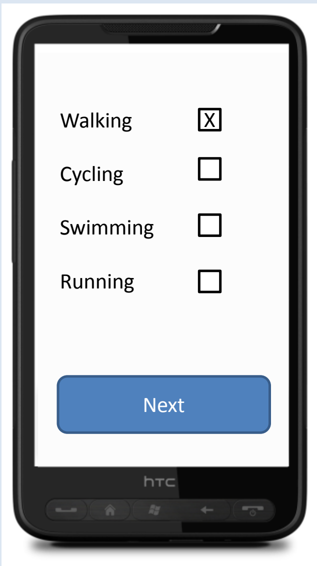
This screen shows a 'garden' display, the height of the flowers shows how many minutes walked, the pink flowers show the goal was completed that day, the blue flowers that the goal was attempted but not reached, and no flower for when the goal was not attempted.

Screen 5	**Strongly Agree**	**Agree**	**Slightly Agree**	**Neutral**	**Slightly Disagree**	**Disagree**	**Strongly Disagree**
Is attractive							
Is confusing							
Would not be useful							
Is easy to understand							

Scenario 2

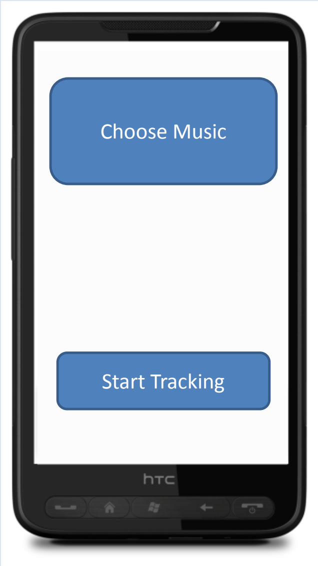


Geoff has COPD, he has been told he needs to increase his physical exercise to 30 minutes a day. He's unsure of how far he walks at the moment so he uses a mobile phone and website to help him make sure he is getting his 30 minutes per day.



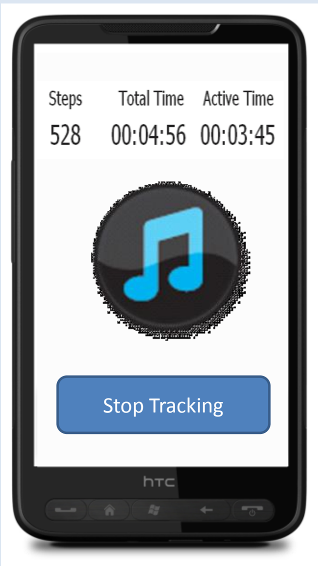
Geoff chooses what activity he wants to do on his mobile phone.

He chooses to walk today.



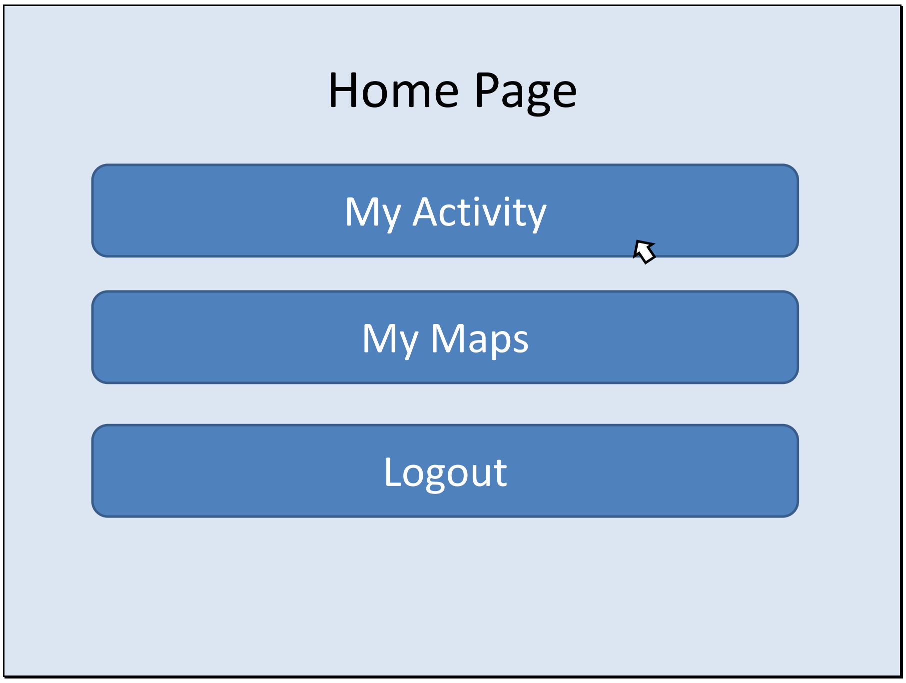
Geoff has headphones for his phone so he can choose to play music while he walks

Geoff then starts 'tracking', this means the phone records information about Geoff's walk.



When Geoff starts tracking, the phone records where Geoff is, how long he has been walking and how many steps he has taken. Geoff can hear the music he's chosen through his headphones

When he has finished his walk, he can stop tracking.



Geoff can look at the computer to see information about the activity he has done.

My Monthly Activity

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

This calendar shows Geoff has completed 3 walks this month, for each walk a summary and map is available

Summary

Activity	Walking
Date	September 5th
Distance	1.3 miles
Time spent	26 minutes 45 seconds
Calories	129 kcal
Weather	Partly sunny
Notes	

Geoff can see the information about each walk summarised. How far he walked, how long it took him, how many calories were burnt and what the weather was like when he did the walk. He can look back at the summaries for all the walks he has done using the system.

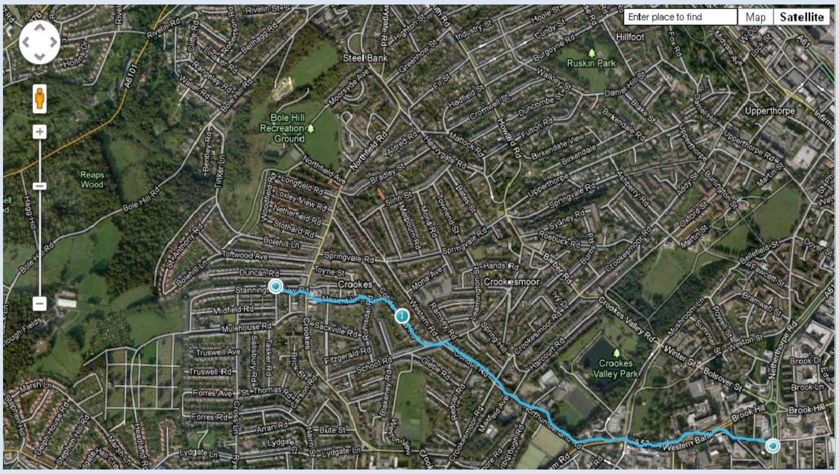
Home Page

My Activity

My Maps

Logout

Map



Geoff can also see a map of where he has walked.

And can choose to see local leisure centres or sports facilities in the area.

Please turn over to answer questions about this scenario.

Imagine you could use this system. Please indicate how much you agree with each of the following statements by ticking the appropriate box. There are no right or wrong answers, we are just interested in your opinion.

Scenario 2 ….	Strongly Agree	Agree	Slightly Agree	Neutral	Slightly Disagree	Disagree	Strongly Disagree
is interesting.							
would have influence on me.							
is personally relevant to me.							
makes me think about my physical activity							

	Strongly Agree	Agree	Slightly Agree	Neutral	Slightly Disagree	Disagree	Strongly Disagree
I would not enjoy using this system							
I think this system would be useful in increasing my physical activity							
If I wanted to increase my activity levels I would not use this system							
This system makes me want to increase my physical activity							
Other comments:							

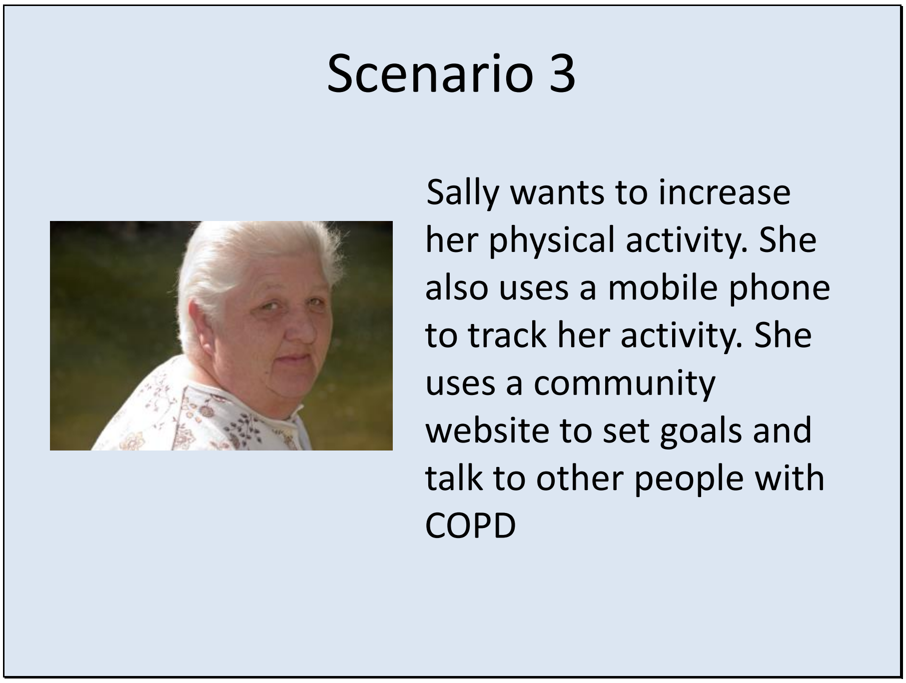
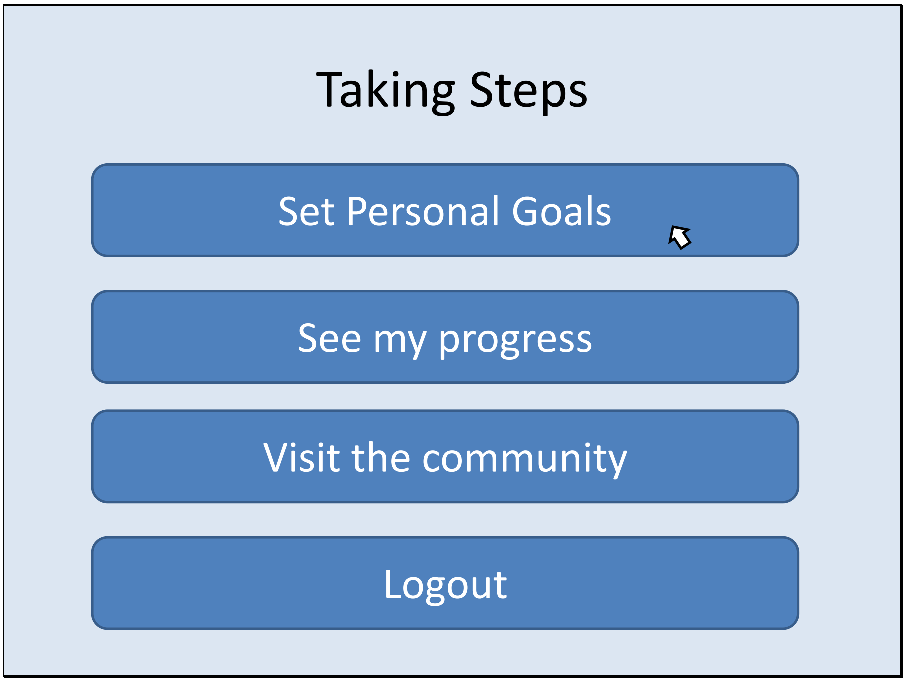
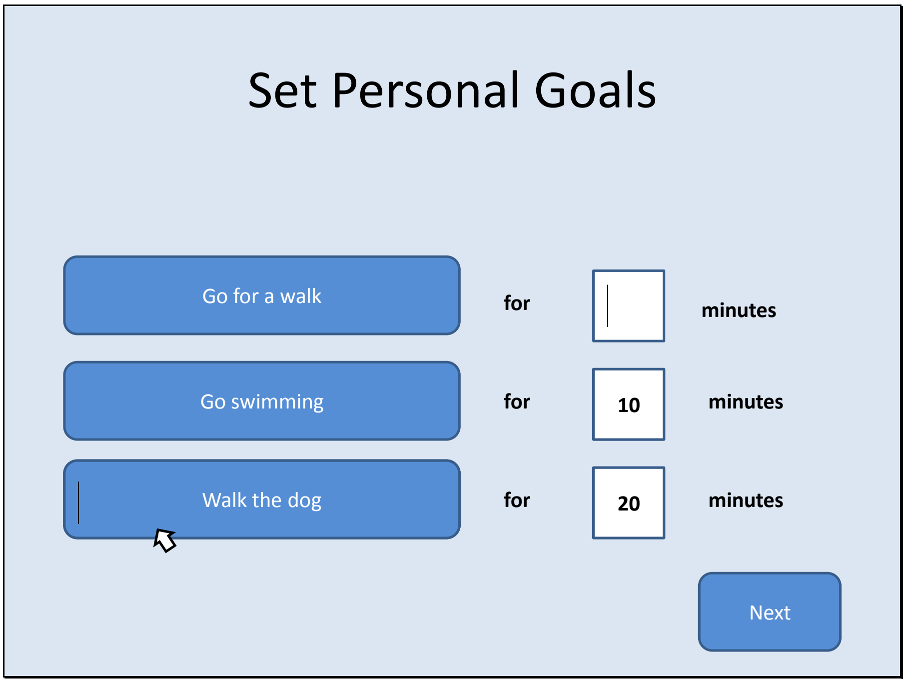


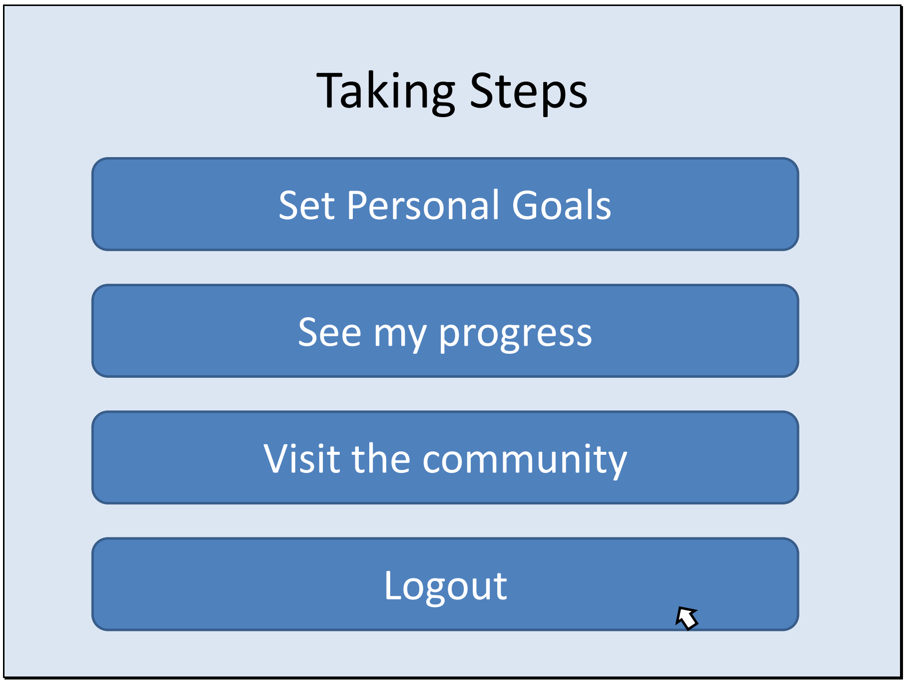
Image courtesy of Abeyer http://www.stockfreeimages.com/



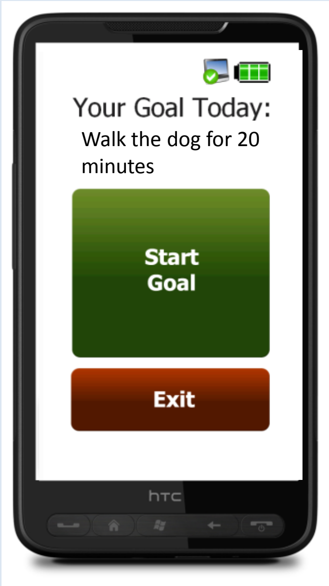
When Sally first uses the website, she can set herself physical activity goals.



Sally enters information about the goal she wishes to complete.



And switches off the computer

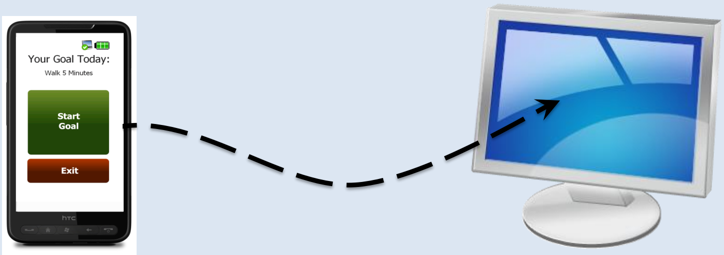


Sally can see the goal she has set herself on her mobile phone.

Sally has a goal of walking the dog for 20 minutes, she can time her walk using her mobile phone.

Sally walks her dog, carrying her mobile phone in her pocket

The information collected on the mobile is then transferred to the website via the internet



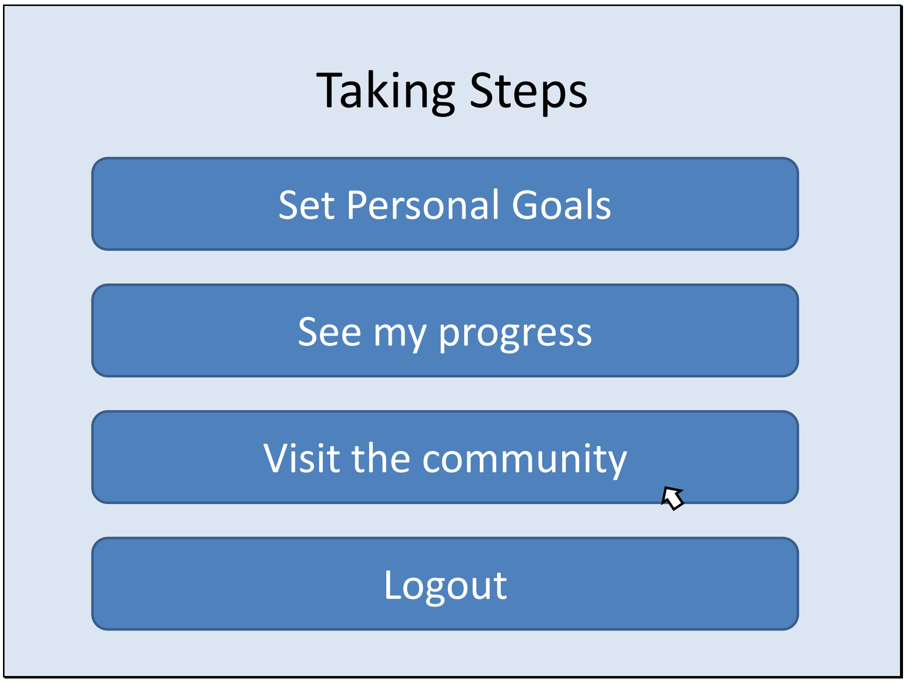
My Progress

Date	Goals Achieved	Points
03/08/2012	Walked for 20 minutes	10
04/08/2012	Went swimming for 30 minutes	10
01/09/2012	Walked for 10 minutes	10
	3 Goals	**30 points**

For every goal achieved, Sally gets 10 points.

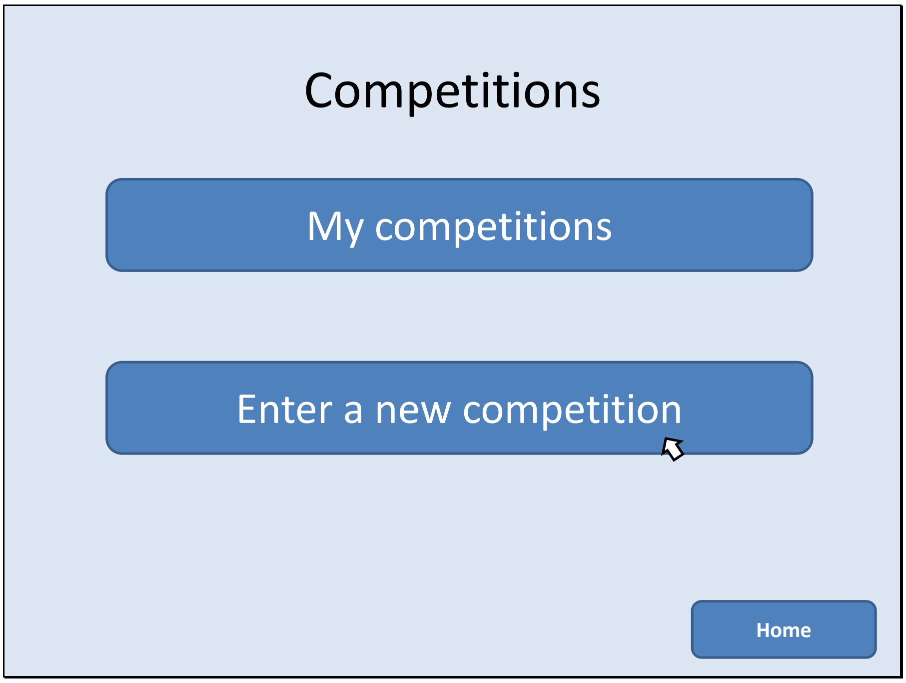
Next

When Sally opens her computer she can see her progress when she visits the website. Points are given for goals completed. So for Sally walking for 20 minutes is a goal. For someone else it might be walking for 5 minutes or for 50 minutes. All these goals would receive 10 points if completed. No one else can see how many minutes Sally has walked to gain the points, just the points she has.



Sally can connect to a community of other people who are using this website from all over the world. She has never met the other people using the community apart from through the website.

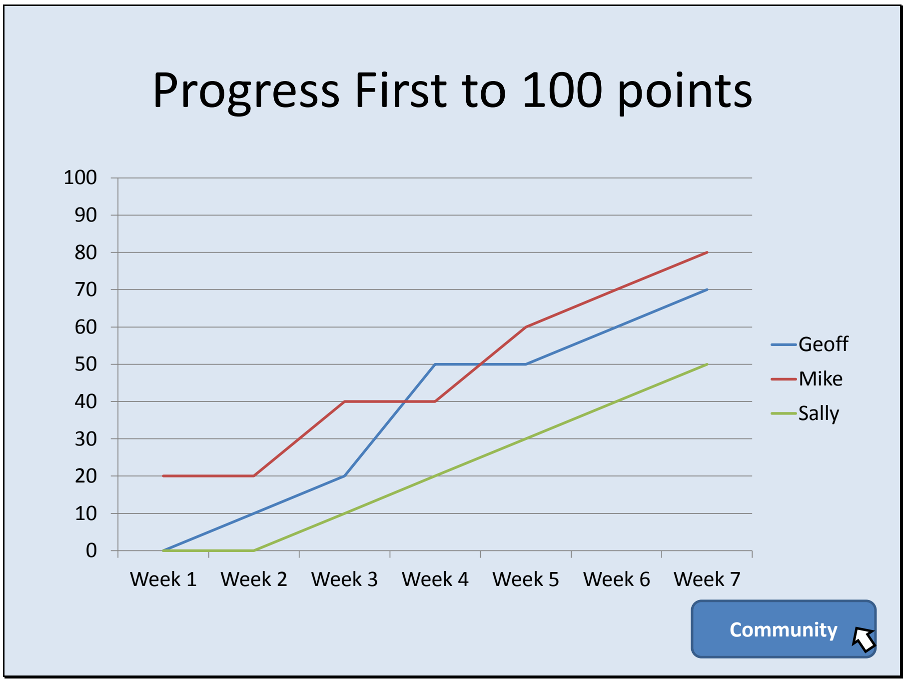
In the 'Community Space' there is an option for Sally to share her profile with other people using the same website. She can chat with fellow members of the community by typing messages and get involved with competitions and team goals.



Sally wants to have a look at what competitions have been suggested by other members of the community

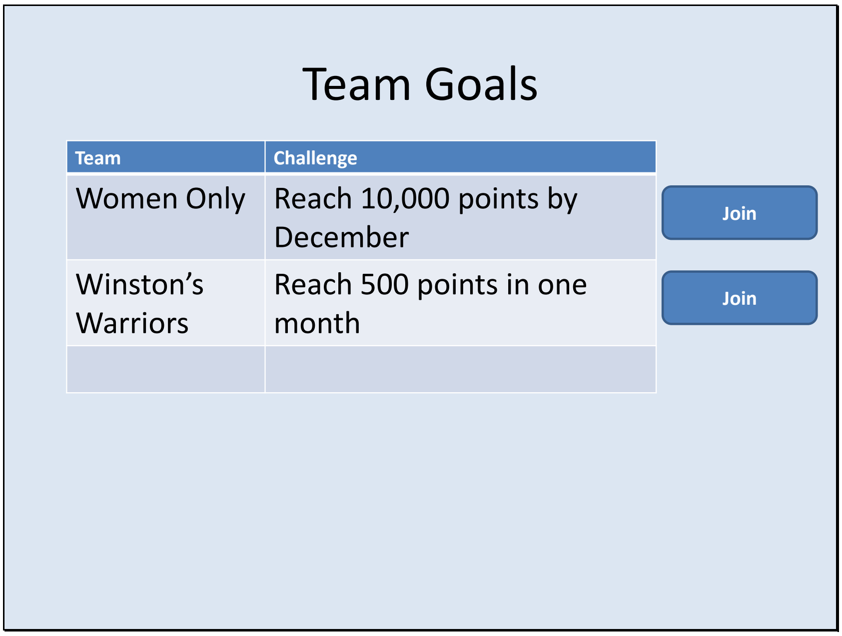
On this screen Sally can see competitions and can accept any she wants to enter.

Sally can see her previous competitions and those she is currently involved with. Other users can send messages about the competitions.



The graph shows how Sally is doing against Geoff and Mike, they are all trying to reach 100 points first.

As well as competitions with other community members, Sally can enter into team goals.



The website provides some goals that can be reached as part of a team. Members can also create their own teams to achieve goals. This allows users to work together and add the points they get together to achieve goals.

Sally also has a ‘profile’ on the website. This is a page with information about her. Everyone on the website has their own ‘profile’ page. She can choose to look at other people’s profiles and to share hers with others.

Sally gets stars and trophies on her profile to show how many points she has. When she has got over 1000 points she can use them to get vouchers to use in shops, or donate to charity. She also has the option to show people how many points she has, and see other people’s profiles.

Please turn over to answer the next questions.

Imagine you could use this system. Please indicate how much you agree with each of the following statements by ticking the appropriate box. There are no right or wrong answers, we are just interested in your opinion.

Scenario 3 ….	Strongly Agree	Agree	Slightly Agree	Neutral	Slightly Disagree	Disagree	Strongly Disagree
is interesting.							
would have influence on me.							
is personally relevant to me.							
makes me think about my physical activity							

	Strongly Agree	Agree	Slightly Agree	Neutral	Slightly Disagree	Disagree	Strongly Disagree
I would not enjoy using this system							
I think this system would be useful in increasing my physical activity							
If I wanted to increase my activity levels I would not use this system							
This system makes me want to increase my physical activity							
Other comments:							

Thinking about the scenarios you've seen, which features do you think would make it more likely for you to use the technology described?

Read the whole list of features. Write a 1 in the rank column next to the feature that would be most likely to convince you to use the technology, then a 2 for the next most important feature then continue to rank as many features as you'd like. Try to rank at least 5 features. If there are any features in the list that would definitely not convince you to use the technology, mark them with an X.

Feature	**Rank**
Conversational/ friendly tone i.e. 'Hi there Joyce'	
Reminder texts	
Goals suggested by the system	
Setting your own goals	
Playing music while you exercise	
Having audio instructions and encouragement while you exercise	
Displaying activity completed in a calendar	
Competitions with other people using technology	
Team goals, to reach with other people	
Displaying the points you have to other people using technology	
Chatting with other people who are using technology	
Seeing a graph of your level of activity	
Tips and advice on performing activity with COPD	
Providing weather information	
Seeing a map of the walks you have done	
Identifying local sporting facilities	

Getting points for completing goals	
Getting stars and/or trophies on your profile for completing goals	
Getting vouchers or coupons for completing goals	
Donating money to charity for completing goals	

Thank you for completing this questionnaire! Your time and effort is very much appreciated!

Please take a moment to check you have completed all the questions.

Post the completed questionnaires with signed, dated consent form using the stamped addressed envelope provided.

If you require any further information about this study, please feel free to contact the researchers at any time. All contact details are provided on the information sheet, which is yours to keep.

ii. Interview guides for stakeholders

Interview Guide for people with COPD

I'm going to talk to you about some different ways technology might be used to help people with COPD to stay active. I'm going to ask you a few background questions and then show you three different examples and ask you what you think. These are only early ideas, so please be honest about what you think, and what you think you might use or not use.

Background questions:

Have you heard of, or seen any technology (websites, mobile phones etc.) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

If yes, give details

Have you ever *used* any technology (websites, mobile phones etc.) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

If yes, give details

Do you *still use* any technology (websites, mobile phones etc.) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

If no, how long did you use it for before you stopped and why did you stop?

If yes, how long have you been using it?

[If this information hasn't been covered earlier in the interview]

Have you ever been advised by a health professional to try and keep active?

Have you completed a course of pulmonary rehabilitation?

If so, when

If not, have you heard about it? Would you consider it?

Do you try to keep active in your everyday life? This might be trying to get up and walk around in the house, or doing some kind of exercise.

If so, why? If not, why is that?

Would you like to increase the amount of activity you do?

Why/why not? What helps/ what stops you?

[All participants]

Talk through each scenario, at this point the interviewer makes really clear to the participant that they should only answer for themselves:

What do you think of that scenario?

Probe for further explanation if not offered

If you wanted to increase your physical activity, do you think you would use this system?

Compare differences between the scenarios they have seen for example, scenario 1 has goals set by the system, in the second scenario you are monitoring your activity and no goals are set for you, what do you think about that?

For feedback screens: I'm going to show you a number of different feedback screens, and ask you what you think of each.

After each feedback screen: What did you think of that? Was it easy to understand? Why do you say that?

Following 5th feedback screen: So which of those do you think would be best? Why is that?

Any other comments? Any particular bits you liked, or didn't like?

<u>Summing up</u>

That's it for examples, **[summarise key points made if possible]**is there anything else you'd like to add about any of these, or any more general comments?

If you were going to use one of those systems, which would you pick? Why is that?

Thank you very much for your time, it's really appreciated.

Interview Guide for health professionals

Background questions:

Have you heard of, or seen any technology (websites, mobile phones etc.) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

If yes, give details

In your professional activities have you ever *used* any technology (websites, mobile phones etc.) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

If yes, give details

In your professional activities do you *still use* any technology (websites, mobile phones etc.) that is designed to try and help change people's behaviours for example increasing exercise, encouraging healthy eating or stopping smoking?

If no, how long did you use it for before you stopped and why did you stop?

If yes, how long have you been using it?

Would you *consider using* such technology in your professional activities in the future?

Why/ why not?

[If this information hasn't been covered earlier in the interview]

What advice do you typically give people with COPD about staying active? Is there anything available to help people with COPD stay active in their everyday lives?

Do you think people with COPD keep active? Why/ why not?

[All participants]

Talk through each scenario, at this point the interviewer makes really clear to the participant that they should only answer for themselves:

What do you think of that scenario?

Probe for further explanation if not offered

Do you think people with COPD would use this system?

Compare differences between the scenarios they have seen for example, scenario 1 has goals set by the system, in the second scenario people with COPD are monitoring your activity and no goals are set for you, what do you think about that?

For feedback screens: I'm going to show you a number of different feedback screens, and ask you what you think of each.

After each feedback screen: What did you think of that? Was it easy to understand? Why do you say that?

Following 5th feedback screen: So which of those do you think would be best? Why is that?

Any other comments? Any particular bits you liked, or didn't like?

<u>Summing up</u>

That's it for examples, **[summarise key points made if possible]** is there anything else you'd like to add about any of these, or any more general comments?

If you were going to recommend one of these systems, or use it with your patients, which would you pick? Why is that?

Thank you very much for your time, it's really appreciated.

iii. Approval letters

ScHARR approval for interviews

The University Of Sheffield.

Kirsty Woodhead
Ethics Committee Administrator

Regent Court
30 Regent Street
Sheffield S1 4DA
Telephone: +44 (0) 114 2225453
Fax: +44 (0) 114 272 4095 (non confidential)
Email: k.woodhead@sheffield.ac.uk

Our ref: 0597/KW

16 October 2012

Gail Mountain
ScHARR

Dear Gail

Technological Platform for Self-Management of CPOD: Development Phase (SMART3).

Thank you for submitting the above research project for approval by the ScHARR Research Ethics Committee. On behalf of the University Chair of Ethics who reviewed your project, I am pleased to inform you that on 16 October 2012 the project was approved on ethics grounds, on the basis that you will adhere to the documents that you submitted for ethics review.

The research must be conducted within the requirements of the hosting/employing organisation or the organisation where the research is being undertaken. You are also required to ensure that you meet any research ethics and governance requirements in the country in which you are researching. It is your responsibility to find out what these are.

If during the course of the project you need to deviate significantly from the documents you submitted for review, please inform me since written approval will be required. Please also inform me should you decide to terminate the project prematurely.

Yours sincerely

Kirsty Woodhead
Ethics Committee Administrator

Email confirmation from the British Lung Foundation

On 19 November 2012 10:24, Tina Patel <Tina.Patel@blf.org.uk> wrote:

Dear Kiera,

This is to let you know that your application has been approved. Could you please contact Lisa Wells, Development Officer for North region (copied) who will be able to assist.

Please do not hesitate to contact me if you have any queries.

Many thanks

Tina Patel
Support Services Secretary

73-75 Goswell Road
London EC1V 7ER

T 020 7688 5574
www.blf.org.uk

R&D approval for staff recruitment

The Rotherham NHS
NHS Foundation Trust

Rotherham Hospital
Moorgate Road
Oakwood
Rotherham
S60 2UD

Telephone 01709 820000
www.therotherhamft.nhs.uk

R&D Reference: ***12-11-06*** **(please quote this number on all correspondence)**

Ms Yvonne Keira Bartlett
ScHARR
The University of Sheffield
Regent Court
30 Regent Street
Sheffield
S1 4DA

Email k.bartlett@sheffield.ac.uk

08 October 2013

Dear Keira,

Re: **Technology based self-management of COPD – SMART 3 COPD**

Sponsor: **The University of Sheffield**

Funder: **MIHR Collaboration for Leadership in Applied Health and Research Care – South Yorkshire (CLAHRC-SY)**

Re: Amendment Protocol 5.1

The following documents have been submitted:-

Document	Version	Date
Protocol (tracked)	5.1	01/08/2013
Sheffield University Ethics Letter of Approval		02/09/2013

These have been reviewed by the Research Office who have no objections to the amendments.

Please ensure a copy of this letter is filed in the Investigator Site File.

Yours sincerely

p.p.

Rotherham Research Alliance
Research & Development, DLE81, D Level, PGME corridor

Leads in Research & Development Miss D Patel & Jo Abbott
Research & Development Manager Dr Sally Atkinson Direct Line 01709 427656/4177 Email sally.atkinson2@rothgen.nhs.uk
In partnership with Rotherham CCG

POSITIVE ABOUT DISABLED PEOPLE

iv. Information sheets and consent forms for the survey study, online and paper

Information Sheet - Online

Using Computers to Increase Physical Activity: The opinions of people with COPD

You are being invited to take part in a survey research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please contact the researcher if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the research about?

Maintaining a healthy level of physical activity is important for everyone. For people with Chronic Obstructive Lung Disease (COPD) keeping fit and active can help to reduce breathlessness and make everyday tasks easier.

We are investigating whether using technology (computers, mobile phones etc.) might help people with COPD to keep active. There is already technology available that helps people monitor their level of activity and provides some motivation to keep active. However, we don't know how people with COPD would feel about this type of technology.

We have designed a survey to gather opinions of people with COPD about this type of technology. There are some background questions about your experiences of physical activity and how familiar you are with different types of technology. Then three different possible scenarios are described. These scenarios are examples of how technology might be used to keep people active. There are pictures of the screens someone would see on their computer, or mobile phone, and each technology is described. The descriptions are clear and 'jargon' free, so you do not need to have used a computer previously to take part. After each of the examples, there are questions asking you about your opinion. These systems have not been built, so please feel free to be honest in your opinions.

Why have I been chosen?

You have been chosen because you have COPD and are a member of a support group, either the British Lung Foundation Breathe Easy support groups, or an online group. We are keen to get a broad range of people involved in this research to get as good idea as possible about what people with COPD think. So anyone can take part, it doesn’t matter if you have never used a computer and/ or mobile phone, or use them all the time, or what your current level of physical activity is.

Do I have to take part?

It is up to you to decide whether or not to take part. Whether you do, or don’t take part will make no difference to your care or the support you receive from other sources. If you do decide to take part you can contact the research team with any questions, at any time. You will also be asked to complete an online consent form. If you do decide to take part, but change your mind, you can still withdraw at any time without it affecting any care or support you receive. You can do this by closing the survey on your computer (the small cross in the top right hand corner), or switching your computer off. You do not have to give a reason.

What do I have to do?

To take part in the research, you have to complete the online survey.

This is a survey study, to take part in the research have to complete the four sections of the survey. This should take around 30 minutes.

Unfortunately, you cannot save the responses half way through and come back to complete it on another day. If you don’t want to complete it all at once, you will need to leave the survey open, and come back to it later. If you close the survey, or turn off your computer, your answers will be lost, and to take part you would need to start from the beginning again.

If you change your mind about participating at any time, simply close the survey and your answers will not be stored.

There is no further obligation and you will not be contacted again unless you choose to receive a summary of the results.

What are the possible disadvantages and risks of taking part?

There are questions relating to your current level of activity and whether you would like to increase this. Some people might find these questions upsetting. Any questions you would prefer not to answer, you can select the 'I prefer not to answer' box and still complete the remaining questions.

What are the possible benefits of taking part?

Whilst there are no immediate benefits for those people participating in the project, this work will contribute to the design of a prototype comprehensive self-management system for people with COPD. We also hope that you will find completing the survey interesting.

What if something goes wrong?

This is a survey study, to gather opinion. It is not advised that participants change their level of physical activity without consulting their health professional.

If you have any questions about this survey please contact Kiera Bartlett on 01142 222 975, or email at k.bartlett@sheffield.ac.uk. If you have any complaints about the conduct of this research, please contact Mark Hawley on 01142 220682 or email at mark.hawley@sheffield.ac.uk.

If, following this, you feel your complaint has not been addressed to your satisfaction, you can contact the University of Sheffield Registrar on 01142 221 100 at registrar@sheffield.ac.uk

If you would like support and information relating to COPD, but not directly related to this research, please contact the British Lung Foundation Helpline on 03000 030 555. Lines are open 10am-6pm Monday to Friday

Will my taking part in this project be kept confidential?

All the information that we collect about you during the course of the research will be kept strictly confidential. No identifiable data (i.e. names or address) will be collected during the course of the research. We will ask for your postcode/ zip code to identify where participants come from, but this will not be linked to a specific address.

What will happen to the results of the research project?

The results of this project will form part of Kiera Bartlett's PhD thesis, they may also be published in peer reviewed journals and/ or presented at conferences. The findings will be used to inform the development of a prototype self-management system for people with COPD. If you would like to be sent a summary of the results of this study, please, email or telephone Kiera Bartlett on 01142 222 975, k.bartlett@sheffield.ac.uk and these will be sent following the end of the study.

Who is organising and funding the research?

This research is being undertaken at the University of Sheffield and Kiera Bartlett is funded by an Engineering and Physical Sciences Research Council PhD Scholarship.

Who has ethically reviewed the project?

This project has been ethically reviewed by the Department of Psychology, University of Sheffield, Ethical Review Board and the British Lung Foundation.

Contact for further information

Thank you for considering this research project. Should you have any questions about this research, either before deciding whether to take part or not, when completing the survey, or following submitting your survey responses, please contact:

Kiera Bartlett
School of Health and Related Research
Regent Court
30 Regent Street
Sheffield
S1 4DA

Tel: 01142 222 975
Email: k.bartlett@sheffield.ac.uk

If you decide you would like to take part, please click the Next button and complete the online consent form. You will not be able to complete the survey unless you agree with all the statements on the consent form. If you do not wish to take part, or would like to think about it or discuss in with others, please feel free to close the browser and re-visit the link if you decide to take part.

Consent Form

Please initial each of the boxes and sign **two copies** of this consent form. Please enclose **one copy** when returning the survey in the stamped addressed envelope to:

Kiera Bartlett, ScHARR, University of Sheffield, Regent Court, 30 Regent Street, Sheffield, S1 4DA

The other copy is yours to keep. If you have any questions about this form, or you do not agree to any of the statements below, please ring Kiera Bartlett on 01142 222975.

Using Computers to Increase Physical Activity: The opinions of people with COPD

Name of Researcher: Kiera Bartlett

Please initial boxes

1. I confirm that I have read and understand the information sheet dated explaining the above research project and I have had the opportunity to ask questions about the project. — —

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. ——

3. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. ——

4. I agree for the data collected from me to be used in future research

5. I agree to take part in the above research project.

_______________________ _______________ ___________________

Name of Participant Date Signature

(*or legal representative*)

___________________________ _________________

____

Lead Researcher Date Signature

Information Sheet – Hard copy

Using Computers to Increase Physical Activity: The opinions of people with COPD

You are being invited to take part in a survey research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please contact the researcher if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the research about?

Maintaining a healthy level of physical activity is important for everyone. For people with Chronic Obstructive Lung Disease (COPD) keeping fit and active can help to reduce breathlessness and make everyday tasks easier.

We are investigating whether using technology (computers, mobile phones etc.) might help people with COPD to keep active. There is already technology available that helps people monitor their level of activity and provides some motivation to keep active. However, we don't know how people with COPD would feel about this type of technology.

We have designed a survey to gather opinions of people with COPD about this type of technology. There are some background questions about your experiences of physical activity and how familiar you are with different types of technology. Then three different possible 'scenarios' are described. These scenarios are examples of how technology might be used to keep people active. There are pictures of the screens someone would see on their computer, or mobile phone, and each technology is described. The descriptions are clear and 'jargon' free, so you do not need to have used a computer before to take part. After each of the examples, there are questions asking you about your opinion. These systems have not been built, so please feel free to be honest in your opinions.

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You have been chosen because you have COPD and are a member of a support group, either the British Lung Foundation Breathe Easy support groups, or an online group. We are keen to get a broad range of people involved in this research to get as good idea as possible about what people with COPD think. So anyone can take part, it doesn't matter if you have never used a computer and/ or mobile phone, or use them all the time, or what your current level of physical activity is.

Do I have to take part?

It is up to you to decide whether or not to take part. Whether you do, or don't take part will make no difference to your care or the support you receive from other sources. If you do decide to take part you can contact the research team with any questions, at any time. You will also find enclosed two copies of a consent form. If you decide to take part please complete both copies. Post one back in the stamped addressed envelope with the completed survey, the other is yours to keep. If you decide to take part, but change your mind, you can still withdraw at any time without it affecting any care or support you receive. If you do not return the survey, you will not be contacted again. You do not have to give a reason.

What do I have to do?

This is a survey study. If you decide to take part you will complete the four sections of the survey. This should take around 30 minutes.

Following this you will need to place the completed survey and one completed consent form in the stamped addressed envelope and post it back to the researcher. This information sheet, and the second copy of the consent form is yours to keep.

Once you have completed the survey and returned it, there is no further obligation.

What are the possible disadvantages and risks of taking part?

There are questions relating to your current level of activity and whether you would like to increase this. Some people might find these questions upsetting. Any questions you would prefer not to answer, you can select the 'I prefer not to answer' box and still complete the remaining questions.

What are the possible benefits of taking part?

Whilst there are no immediate benefits for those people participating in the project, this work will improve our understanding of the opinions of people with COPD and contribute to the design of a prototype comprehensive self-management system for people with COPD. We also hope that you will find completing the survey interesting.

What if something goes wrong?

This is a survey study, to gather opinion. It is not advised that you change your level of physical activity without consulting your health professional.

If you have any questions about this survey please contact Kiera Bartlett on 01142 222 975, or email at k.bartlett@sheffield.ac.uk. If you have any complaints about the conduct of this research, please contact Mark Hawley on 01142 220682 or email at mark.hawley@sheffield.ac.uk.

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Will my taking part in this project be kept confidential?

All the information that we collect about you during the course of the research will be kept strictly confidential. Your name and address will be collected to send you out a copy of the survey, but following this they will be destroyed and won't be linked to the returned survey. Your answers will only be identified by a participant number.

What will happen to the results of the research project?

The results of this project will form part of Kiera Bartlett's PhD thesis, they may also be published in peer reviewed journals and/ or presented at conferences. The findings will be used to inform the development of a prototype self-management system for people with COPD. If you would like to be sent a summary of the results of this study, please, email or telephone Kiera Bartlett on 01142 222 975, k.bartlett@sheffield.ac.uk and these will be sent following the end of the study.

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Contact for further information

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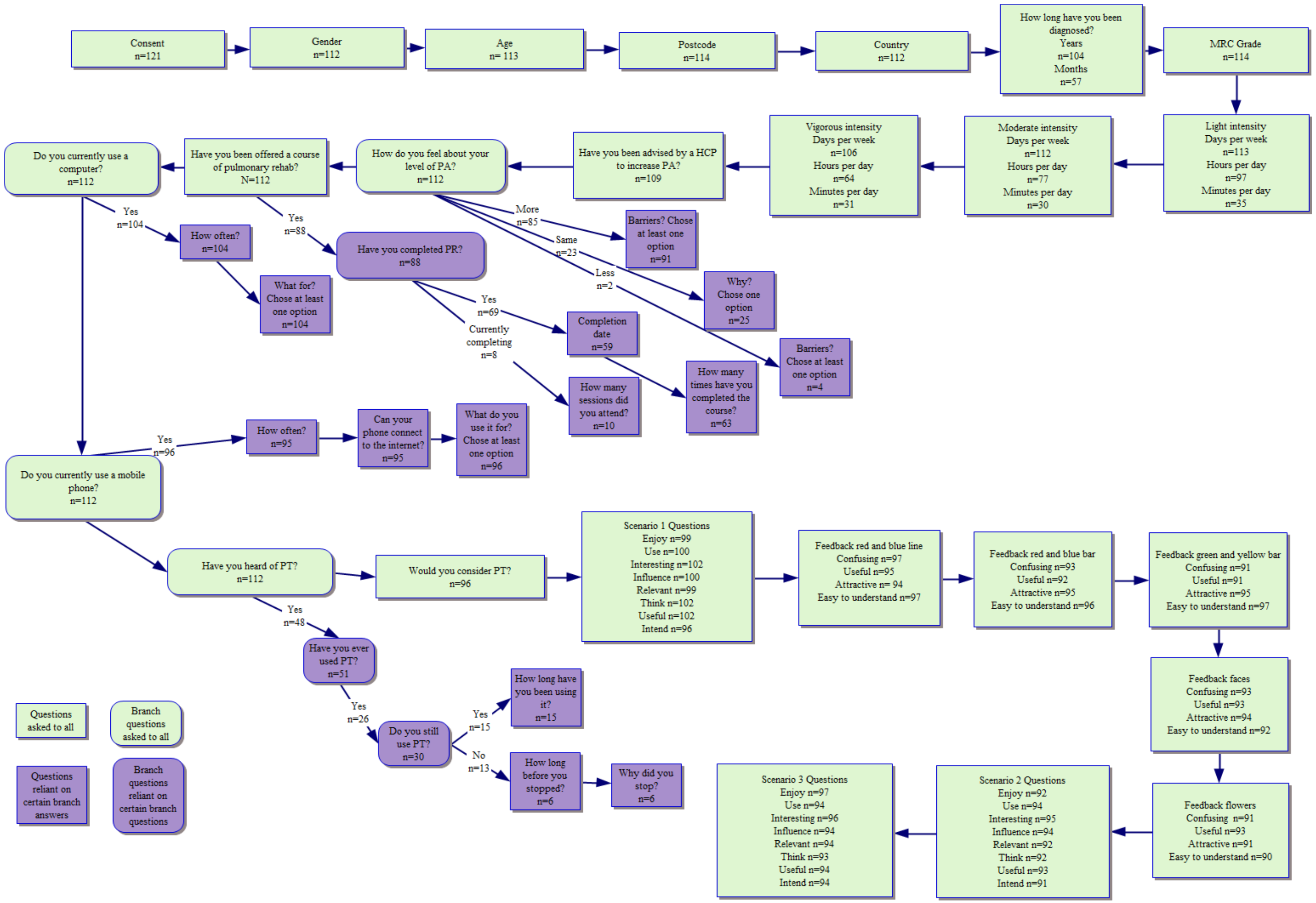
Kiera Bartlett
School of Health and Related Research
Regent Court
30 Regent Street
Sheffield
S1 4DA

Tel: 01142 222 975
Email: k.bartlett@sheffield.ac.uk

If you decide you would like to take part, please complete both copies of the consent form and the enclosed survey. Please check through the survey to ensure you've answered all the questions you need to.

Once completed please return the completed survey and one completed consent form to Kiera Bartlett in the stamped addressed envelope.

v. Flow of Participants through the survey



vi. Integration matrix

Data type	Interview	Survey	Comments on integration
Sample characteristics			
Impact of COPD	Not assessed formally 11/16 reported needing help when walking outside, which could indicate MRC 3, 4 or 5. Only one person mentioned that COPD did not impact that much on their life	Modal response of MRC breathlessness grade 4	Both samples indicated they were towards the more severe end of breathlessness/ impact. Mild COPD under-represented in both samples.
Current activity levels	Not assessed formally, participants discussed the impact COPD had on their activity levels and the difficulty with getting outside	Higher than the average older adult in England.	Potentially the interview sample were less active than the online sample, but it's unclear what the average would be for people with COPD.
Perceived impact of activity levels on opinions expressed	The importance of setting initial goals that were sensitive to a person's current level of activity and continually regulating goals so they remain appropriate for the person's physical capability. Those with lower mobility indicated that none of the systems would be suitable for them.	Participants expressed that if they were already active the persuasive technology was not needed, and if they were unable to be active the persuasive technology would not be useful	Both sources confirmed that if someone was unable to be active, none of the systems would be useful for them. In the surveys those who were already active also indicated that persuasive technology would not be needed.
Current use of technology	Most had a mobile phone, but sometimes they rarely used it. Very low familiarity with persuasive technology devices	Just under half used a mobile daily. Higher familiarity with persuasive technology devices than the PwCOPD interviewed	Those completing the online survey had greater familiarity with persuasive technology and more frequent mobile use.

Data type	Interview	Survey	Comments on integration
Perceived impact of technology use on opinions expressed	Concerns were raised that the technology may not be understood by PwCOPD (concerns raised by HCPs/ PwCOPD and carers).	The potential for the technology to be too complicated for people was mentioned in the negative comments made about the scenarios. Some negative comments about the use of technology generally.	Confirmation from both sources that some members of this population would not be that familiar and comfortable with technology. The survey produced more strongly expressed negative opinions about technology in general than the interviews did.
Opinions			
Virtual Coach	HCPs were very positive. PwCOPD indicated it would suit those who were mobile but less motivated than themselves, also people who lived alone.	Perceived as the most persuasive. Both positive and negative comments were expressed, the negative comments were more emotive than those expressed during the interview	Broad confirmation, both samples agreed this scenario was persuasive although the PwCOPD who were interviewed were less positive than either those who answered the survey or the HCPs who were interviewed. The survey was supposed to address the potential problems caused by social desirability in the interview setting, the strongly negative comments could indicate it achieved this aim. Or could be evidence that people who are protected by the anonymity of the internet, express their views more negatively.

Data type	Interview	Survey	Comments on integration
Music and Maps	Could be interesting for those who walk outside, but the more active involvement of the VC was thought to be needed too. For some HCPs it was similar to systems they had used already. Walking with music was divisive, some thought it would be dangerous, also maps would be less useful for those who walk in an area they know or do the same walk	Perceived as significantly more persuasive than OC and significantly less persuasive than VC. Walking with headphones might be dangerous, the data that was provided in the MM scenario was good, but it would not be useful for those who knew the area they were walking in.	Very similar comments made, confirmatory
Online Community	The most divisive scenario, especially the competitive aspect. HCPs and some carers and PwCOPD expressed negative opinions about competition, these ranged from worrying about people feeling disheartened to worrying that some people would cheat. Participants were more positive about the social support aspects, but felt their success would be down to the individuals involved and their preferences for social support through this medium.	Perceived as significantly less persuasive than MM and VC. Furthermore, all the features on their own were also ranked significantly lower than those associated with VC and MM. Some people expressed positive comments relating to both the competition and the social support aspects, however there were also strongly worded negative comments.	Discordant findings. In both cases divisive, but the interview participants (PwCOPD) may have been more positive about this scenario than the survey participants. Interesting as survey participants are mostly members of online support groups.
Feedback screens	The importance of comparison was highlighted, and the different views on displaying negative feedback	No comments sought, see below for preferences	No integration possible, no opinions sought on the feedback screens in the survey.
Features	Reminders were identified as useful. Competition, social support, setting your own goals, having the technology set goals for you, maps and audio were all seen as both positive and negative by different people and rewards were not thought to be useful.	Tips and advice and setting your own goals were the most highly ranked features. Those associated with both MM and VC were ranked significantly higher than features associated with OC	Expansive, further detail available from the interviews, but not really discordant or confirmatory.

Data type	Interview	Survey	Comments on integration
Goals	PwCOPD would only accept technology setting the goal if it was appropriate, in terms of level, setting and interests. HCPs were concerned that PwCOPD setting their own goals would not challenge themselves enough.	The feature setting own goals was rated more positively than goals set by the system, although both appeared in the top 10.	Expansive, those interviewed could identify the caveats that were deemed necessary before technology could be used to set goals, but overall across the two strands, PwCOPD were slightly more wary about technology setting goals, but relatively supportive of both.
Preferences			
Scenarios	PwCOPD preference for OC, HCPs preference for VC, overall VC, then MM and OC tied. All very close.	Preference for VC, then MM, then OC	PwCOPD in the interview were more positive about the OC scenario than those in the survey. Otherwise broadly confirmatory
Feedback screens	FB2 was rated highest, and FB5 rated lowest	FB2 was rated highest, and FB5 rated lowest	Confirmatory