Interactive Technology to Support Physical Activity in Chronic Pain Self-Management: An Investigation of User Needs

Talia Swann-Sternberg

Project report submitted in part fulfilment of the requirements for the degree of Master of Science (Human-Computer Interaction with Ergonomics) in the Faculty of Life Sciences, University College London, 2011.

NOTE BY THE UNIVERSITY

This project report is submitted as an examination paper. No responsibility can be held by London University for the accuracy or completeness of the material therein.
ACKNOWLEDGMENTS

I would like to thank Dr Nadia Berthouze for her guidance, support, and enthusiasm throughout this project, Dr Amanda C de C Williams for her feedback, especially her invaluable help on the questionnaire, Aneesha Singh for her support and detailed, insightful feedback on my thesis, and to all the participants for their time, effort, and interest in this project.

I would also like to thank my parents for their feedback on and proofreading of the questionnaire and multiple thesis drafts, and my husband for being an unending source of support and motivation.
ABSTRACT

Chronic musculoskeletal pain is a widespread health concern with large costs to individuals’ quality of life and to society through healthcare expenses and lost work. Multidisciplinary pain management programmes address the multifaceted experience of chronic pain, which includes physical and psychological components. These programmes enable patients to improve their functioning by teaching them the skills to manage their pain. However, long-term success of these programmes remains limited by poor adherence to self-management behaviours, including regular exercise. However, regular physical activity is an important pain management behaviour associated with improved patient outcomes.

Technology provides new opportunities for cost-effective support for exercise adherence in chronic pain self-management. The e-health field has investigated providing technology-based chronic pain services while the field of persuasive technology has investigated technology-based systems for encouraging exercise in healthy users. However, these areas have not addressed the issue of long-term exercise adherence in people with chronic pain, who have unique needs with respect to physical activity.

The present study explored how an interactive technology could support people with chronic musculoskeletal pain to maintain regular physical activity. Applying recommended methods for the design of patient-centred e-health, user needs were explored through interviews and a questionnaire. Semi-structured interviews were conducted with people with chronic musculoskeletal pain and physiotherapists; interview transcripts were analysed using grounded theory. A questionnaire based on the results of early interviews was distributed to people with chronic musculoskeletal pain to validate and expand upon interview data.

The results suggest a number of user requirements for physical activity support in the chronic pain population, many of which are not addressed by current technologies aimed at increasing physical activity in the general population or by e-health systems for the chronic pain population. Our findings suggest several areas requiring future research and contribute to the development of an interactive technology to support physical activity in chronic pain self-management.
# CONTENTS

Chapter 1. Introduction .................................................................................................................. 6
Chapter 2. Literature Review ......................................................................................................... 7
  2.1 Chronic Pain Management ..................................................................................................... 7
    2.1.1 Exercise adherence ....................................................................................................... 7
  2.2 E-Health .................................................................................................................................. 8
  2.3 Persuasive Technology ......................................................................................................... 9
    2.3.1 Virtual coach ............................................................................................................... 9
    2.3.2 Exercise monitoring ................................................................................................. 10
    2.3.3 Goals and Progress tracking .................................................................................... 11
    2.3.4 Encouragement and Positive Reinforcement .......................................................... 12
  2.4 Implications of Research ...................................................................................................... 13
Chapter 3. Methods ....................................................................................................................... 14
  3.1 Interviews ............................................................................................................................ 14
    3.1.1 Participants .............................................................................................................. 14
    3.1.2 Ethics ....................................................................................................................... 15
    3.1.3 Materials ................................................................................................................. 15
    3.1.4 Analysis ................................................................................................................... 15
  3.2 Questionnaire ...................................................................................................................... 15
    3.2.1 Participants .............................................................................................................. 16
    3.2.2 Ethics ....................................................................................................................... 16
    3.2.3 Materials ................................................................................................................. 16
    3.2.4 Analysis ................................................................................................................... 16
Chapter 4. Results: Interviews ..................................................................................................... 17
  4.1 Pain Management Approach ............................................................................................... 19
    4.1.1 Correct Posture ........................................................................................................ 19
    4.1.2 Body Awareness ...................................................................................................... 20
    4.1.3 Pacing ..................................................................................................................... 20
    4.1.4 Cognition & Affect ................................................................................................. 21
  4.2 Personalisation ..................................................................................................................... 21
  4.3 Supportive Functions ........................................................................................................... 21
    4.3.1 Education ................................................................................................................. 22
    4.3.2 Detecting Physical Problems ................................................................................... 22
    4.3.3 Tailored Exercise Programme ................................................................................ 22
    4.3.4 Exercise Demonstration ......................................................................................... 23
    4.3.5 Posture Correction ................................................................................................. 23
    4.3.6 Exercise Monitoring ............................................................................................... 23
    4.3.7 Information Tracking ............................................................................................. 24
  4.4 Encouraging Adherence ....................................................................................................... 25
    4.4.1 Managing Expectations/Goals ............................................................................... 25
    4.4.2 Managing Flare-ups/Setbacks ............................................................................... 25
    4.4.3 Forming/Maintaining Habit .................................................................................... 26
    4.4.4 Encouragement/Positivity ...................................................................................... 26
    4.4.5 Engagement ........................................................................................................... 27
  4.5 Visual Representations ......................................................................................................... 27
    4.5.1 Body Image .............................................................................................................. 27
    4.5.2 Virtual Coach Appearance .................................................................................... 28
    4.5.3 User Avatar Appearance ......................................................................................... 28
CHAPTER 1. INTRODUCTION

Chronic pain, defined as pain without apparent biological value that has persisted beyond the normal tissue healing time (Harstall & Ospina, 2003), is a complex experience affecting patients’ physical, psychological, and social functioning (Ashburn & Staats, 1999; Turk & Okifuji, 2002). Pain affects almost 10 million Britons daily, and although the exact costs of chronic pain are unknown, the cost of back pain to the UK exchequer is an estimated £5 billion annually (“The British Pain Society - FAQs,” 2008). In most cases, chronic musculoskeletal pain cannot be cured; instead, patients must learn to manage their pain (Ashburn & Staats, 1999; Du et al., 2011). The British Pain Society (2007) identifies multidisciplinary pain management programmes (PMPs) as the treatment of choice for chronic pain. The aim of PMPs is to teach patients the skills required to manage their pain independently (British Pain Society, 2007). These programmes require that patients adopt new behaviours such as regular performance of physical exercises and use of coping strategies (Turk & Okifuji, 2002). Although PMPs help many individuals with chronic pain to improve their quality of life, many people struggle to maintain the lifestyle changes necessary for long-term pain management (Turk & Okifuji, 2002).

Technology provides new opportunities for supporting people in the management of chronic conditions (Garcia-Lizana & Sarria-Santamera, 2007). The fields of e-health and persuasive design have explored the use of technology in healthcare and wellness. Although some studies have explored how technology can help people with chronic pain (Keogh, Rosser, & Christopher Eccleston, 2010), there is little information regarding how to support regular physical activity, an important part of chronic pain self-management. In her thesis examining obstacles to adoption of and adherence to self-management of chronic musculoskeletal pain, O’Connor (2008) established a number of user needs for a supportive technology. The current study further explores these needs, focussing specifically on exercise adherence following supervised self-management during a PMP or other structured treatment. To investigate how exercise adherence can be supported by an interactive technology, we: (1) reviewed literature on the use of technology in chronic pain treatment and in physical activity support for healthy users; (2) interviewed people with chronic musculoskeletal pain and physiotherapists experienced with chronic pain treatment to explore patient needs and expectations of an interactive support system; and (3) distributed a questionnaire to people with chronic musculoskeletal pain to validate and extend results from early interviews.

The current study is presented as follows: Chapter 2 provides background information by reviewing research on chronic pain management, e-health support of pain management, and persuasive technologies for encouraging exercise; Chapters 3 details the methods of the present research; Chapters 4 and 5 present interview and questionnaire results, respectively; Chapter 6 discusses the results in the context of previous research, theories of behavioural change, limitations of the present study, and future research directions; and Chapter 7 concludes the study with a summary of this study’s main findings and contributions.
CHAPTER 2. LITERATURE REVIEW

This chapter reviews relevant research on chronic pain management, e-health in the field of chronic pain management, and persuasive technologies designed to encourage physical activity. This chapter aims to provide background information on existing research into technology-based health support systems, as well as highlight the need to draw on lessons from the persuasive design field in order to design e-health systems for long-term support of chronic pain management.

2.1 Chronic Pain Management

Chronic pain negatively impacts patients’ physical, psychological, and social functioning (Ashburn & Staats, 1999; Turk & Okifuji, 2002). Multidisciplinary PMPs have gained popularity in recent years as a comprehensive approach to addressing the many facets of living with chronic pain (Oslund et al., 2009). The British Pain Society (2007) identifies PMPs as the “treatment of choice for people with persistent pain that adversely affects their quality of life” (p. 1). According to the British Pain Society (2007),

PMPs consist of education on pain physiology, pain psychology, healthy function and self-management of pain problems; and of guided practice on setting goals and working towards them, identifying and changing unhelpful beliefs and ways of thinking, relaxation, and changing habits which contribute to disability. Participants practise these skills in their home and other environments to become expert in their application and integration (p. 1).

A meta-analysis investigating the efficacy of multidisciplinary PMPs found that these programmes should include individual exercises, regular training in relaxation techniques, group therapy, patient education sessions, physiotherapy sessions based on cognitive behavioural therapy (CBT) to establish pacing strategies, medical training therapy, and neurophysiology information provided by a physician (Scascighini, Toma, Dober-Spielmann, & Sprott, 2008). Such multidisciplinary programmes showed improved efficacy over standard medical treatment and non-multidisciplinary treatments (Scascighini et al., 2008). The skills PMP patients learn include maintaining a regular exercise routine to build fitness and mobility and to improve confidence in physical activity, pacing activities, setting goals, using cognitive therapeutic skills, using relaxation skills, and managing flare-ups and setbacks (British Pain Society, 2007).

2.1.1 Exercise adherence

A major obstacle to successful management of chronic musculoskeletal pain is poor adherence to home exercise (Medina-Mirapeix, Escolar-Reina, Gascón-Cánovas, Montilla-Herrador, & Collins, 2009). Estimates of the percentage of people with chronic pain who do not perform home exercises as prescribed range due to variation in measures and definitions of adherence, but the value can be approximated at 50% or greater (Medina-Mirapeix et al., 2009). However, continued regular exercise following chronic back pain treatment is associated with better long-term outcomes with respect to pain (Petersen, Larsen, & Jacobsen, 2007; Taimela, Diedrich, Hubsch,
One barrier to exercise in individuals with chronic pain is pain-related fear of movement. Although pain-related fear is an adaptive response to acute pain because it promotes care behaviours, including activity avoidance to allow healing, it can be maladaptive in chronic musculoskeletal pain, where pain may no longer indicate injury (Leeuw et al., 2006). The fear-avoidance model posits that people with chronic back pain avoid certain movements due to their fear of pain and/or causing (re)injury (Leeuw et al., 2006). The model suggests that this fear of pain/injury results from the belief that pain is necessarily a sign of physiological damage, a belief that leads to pain catastrophising, or the interpretation of pain as extremely threatening (Leeuw et al., 2006). Although PMPs include interventions targeting fear-avoidance, efficacy studies show mixed results (Pincus, Smeets, Simmonds, & Sullivan, 2010). Thus, it is likely that fear remains an obstacle to exercise for some people even after completing a PMP.

Additional factors reported to influence exercise adherence are exercise supervision, physiotherapy follow-up sessions, and the type of support provided by one’s physiotherapist. In a review of 16 randomised controlled trials, Liddle, Baxter, and Gracey (2004) reported that supervised strength, stabilisation, and flexibility exercises improved back function more than instruction to do a home exercise programme. Although follow-up sessions do not provide the same level of supervision as ongoing supervised exercise, regular follow-ups with physiotherapists may provide patients with increased motivation to continue home exercise (Ljunggren, 1997). The type of interaction patients have with physiotherapists can also influence exercise compliance. For example, adherence to exercise programmes was reported to be significantly higher when physiotherapists regularly monitored exercise performance, asked for patient feedback about progress and treatment, provided positive feedback, and frequently motivated patients to do home exercises (Sluijs, Kok, & van der Zee, 1993).

Although methods for improving exercise adherence have been identified, ongoing supervision of exercises and follow-up sessions require considerable resources, making them impractical solutions with the current rising financial pressure on the healthcare systems of many countries (Chiasson, Reddy, Kaplan, & Davidson, 2007). Alternative cost-effective means of support must be found to increase patient home exercise compliance and thereby improve chronic pain outcomes.

2.2 E-Health

E-health, defined as the use of information and communication technology to aid or provide healthcare (Keogh, Rosser, et al., 2010), has been shown to be a cost-effective method of treatment for chronic pain management (Pronovost, Peng, & Kern, 2009). However, e-health for chronic pain has largely been modelled on in-person PMPs, including their finite duration, and therefore has not addressed the obstacles to long-term self-management (e.g. Brattberg, 2007; Buhrman, Fältenhag, Ström, & Andersson, 2004). PMPs of longer duration often produce greater patient change, but programme durations are subject to economies of time and resources (British Pain Society, 2007). While e-health PMPs could have longer durations due to decreased costs, technology also offers the unique opportunity for indefinite pain management
support. One project taking advantage of this opportunity is SMART2, a project in which researchers have investigated both how to adapt face-to-face therapeutic practice to technology-based formats and how to encourage sustained use (Rosser, McCullagh, et al., 2011). SMART2 focussed on pacing, a common component of multidisciplinary PMPs that targets the maladaptive cycle of activity avoidance during periods of high pain followed by compensatory over-activity. Based on focus groups with healthcare professionals and individuals with chronic pain, the researchers proposed a mobile device for monitoring activity and providing feedback and a home-based device for activity planning and progress feedback. The project is a preliminary step towards supporting chronic pain self-management and leaves many areas for additional research. In particular, Rosser et al. (2011) emphasise that the system must dynamically respond to the user’s current behaviour (e.g., activity pattern) and experience (e.g., affective state) but do not detail how the system should change in response to these factors. Also, the researchers addressed only one pain management behaviour (pacing), excluding, among other behaviours, regular exercise.

2.3 Persuasive Technology

Maintaining a regular exercise routine is a challenge for many individuals (Haskell et al., 2007), not only those with chronic pain; supporting this behaviour is an active area of research within the persuasive technology field. Persuasive technology is technology designed with the intention of supporting the change of a person’s behaviours and/or attitudes (Fogg, 1998). Although individuals with chronic pain have unique needs associated with physical activity, such as addressing the fear of movement, research in persuasive technology for non-pain populations nevertheless provides insight into what factors can support adoption of regular exercise as a lifestyle change. Indeed, research on persuasive exercise technologies has addressed the factors identified to increase exercise adherence in people with chronic pain, namely personalised feedback, progress tracking, and encouragement/positive feedback. This section addresses these factors, and other methods of supporting physical activity, in the following sub-sections: virtual coach, exercise monitoring, goals and progress tracking, and encouragement and positive feedback.

2.3.1 Virtual coach

One opportunity for persuasion with technology results from users’ tendency to respond to computers as social actors when computers contain animate characteristics, play animate roles, or follow social dynamics (Fogg, 1998). Social actors can persuade by establishing social norms, invoking social rules, and providing social support (Fogg, 1998). Several technologies for encouraging physical activity have incorporated a social actor through the metaphor of a fitness coach who demonstrates movements, gives feedback, and provides encouragement.

Ijsselsteijn et al. (2006) developed an embodied virtual coach to increase motivation for engaging in physical exercise. In response to heart rate information, the virtual coach told participants, who were riding a stationary bicycle, to do better, that they were doing great, or to slow down. An evaluation study with participants who did not regularly exercise indicated that the coach was perceived as useful but did not increase internal motivation. However, the coach did significantly decrease scores of pressure and tension. The authors explain this by suggesting that the participants felt
comfortable relying on the coach’s instructions, which in turn decreased some stress or uncertainty. In contrast to Ijsselsteijn et al.’s (2006) findings, in a comparison of motivation in 20 participants who cycled either with or without a virtual coach, Eyck et al. (2006) found that participants with the virtual coach, who gave feedback based on the user’s heart rate, gave significantly higher ratings of their interest/enjoyment than those without the coach. Eyck et al. (2006) suggested that the different findings may have resulted from their virtual coach delivering more diverse and extensive sentences than Ijsselsteijn et al.’s (2006) coach.

Ijsselsteijn et al.’s (2006) virtual coach used imperatives to incite users (e.g. “Your heart rate is slow! Run faster!”). In contrast, Buttussi et al. (2006) created an embodied virtual trainer that made suggestions and highlighted the positive (e.g. “You are walking regularly. If you are not tired, try to increase your speed”). This mobile virtual trainer provided audio feedback and demonstrated exercises when users reached outdoor gyms. Feedback indicated that the twelve participants in the study, on average, responded moderately positively to the virtual coach. Some users commented that they would have preferred a gentler coaching style. This varied personal preference for coaching style was also found by Asselin et al. (2005), who reported that some users preferred a soft female voice for the unembodied virtual coach while others preferred a militant drill sergeant’s voice. In tests of Asselin et al.’s (2005) system with 65 participants, many users commented favourably on the virtual coach’s auditory feedback, which included encouragement to either speed up or slow down according to the user’s heart rate and target heart rate. In addition to assessing user reactions to the virtual coach, Buttussi et al. (2006) also evaluated accuracy of exercise movements and found that participants performed exercises significantly more accurately when they saw a virtual coach demonstration as compared with seeing only static diagrams. In an evaluation of another virtual coach that provided exercise demonstrations and feedback, interviews with ten users indicated that most liked the virtual trainer and would use it if it offered more tailored feedback relevant to their individual needs (Ruttkay & Welbergen, 2008).

Evaluations of the effect of a virtual coach on exercise remain limited. Nevertheless, the coach paradigm appears to have potential for providing healthy users with instruction and feedback, as well as possibly increasing motivation and engagement. A virtual coach may be an effective means of providing the exercise monitoring, positive feedback, and encouragement identified to increase exercise adherence in the chronic pain population. In addition, Ijsselsteijn et al.’s (2006) finding of participants’ reduced pressure/tension suggests that guidance from a virtual coach could potentially alleviate some of the exercise anxiety that people with chronic pain often experience due to pain-related fear. These studies also suggest that virtual coaches may benefit users by demonstrating exercises and increasing enjoyment.

2.3.2 Exercise monitoring

Many technologies designed to encourage physical activity help users monitor their exercise, thereby allowing them to evaluate their performance. Asselin et al.’s (2005) wearable device provided audible counting of repetitions for anaerobic exercises, and while it did not report the user’s precise heart rate, it indirectly communicated this information both by telling users to speed up or slow down and through the rate of music playback. Many users commented positively on the ongoing feedback during aerobic exercise.
Technology can also allow visual monitoring of movements through the use of video or avatar representations of the user. For their system to support home exercise, Cui et al. (2009) distributed a survey to 30 participants to explore preferences for three different types of avatars: a depersonalised skeletal model, a semi-personalised model that reflected the user’s body type, and a personalised mirror-image model created from photographs of the users. Cui et al. (2009) reported that from the three possible avatars, most participants preferred the semi-personalised avatar.

The use of an avatar to display a user’s movements also provides the opportunity for the system to give the user corrective feedback. For example, *Your Shape: Fitness Evolved* (Ubisoft Entertainment, 2010) for the Xbox Kinect utilises the user’s avatar to provide additional feedback such as highlighting areas of the body while providing auditory corrective feedback, e.g. “arms a little lower” (see Figure 1).

![Figure 1. Example user avatar from *Your Shape: Fitness Evolved* (Ubisoft Entertainment, 2010) for the Xbox Kinect](image)

No studies have evaluated the effect this type of feedback has on users. However, insofar as interactions with real fitness coaches or physical therapists can be used as a guide for the design of feedback provided by fitness technology, corrective feedback would likely be a beneficial addition to a technology’s programme.

These technologies suggest that auditory and visual forms of exercise monitoring may benefit the user but that user preferences for different implementations should be explored.

### 2.3.3 Goals and Progress tracking

One of the ways in which computers can persuade is by reducing the barriers, such as time and effort, to a behaviour (Fogg, 1998). Setting goals and tracking progress can increase self-motivation (Bandura, 2001), but tracking progress requires an investment of time and effort. Technology can assume the burden of tracking information, thereby enabling easy progress monitoring. For example, Asselin et al.’s (2005) personal wellness coach stored information on repetitions and weights from anaerobic exercise and laps and duration from aerobic exercise. Users who valued the anaerobic mode highlighted this record keeping of exercise performance as beneficial.

Several studies have evaluated the effect of abstract representations of people’s progress towards goals for physical activity. To encourage aerobic activity, Lin et al. (2006) developed the Fish ‘n’ Steps game. Nineteen participants set goals for daily...
number of steps, wore pedometers, and reported their daily step counts, which were entered into the system. Each participant’s activity was reflected in the happiness and growth of a virtual fish. The majority of participants increased their number of daily steps and/or had a positive change in attitude towards physical activity during the 14-week trial. In another effort to increase people’s physical activity, Consolvo, Klasnja et al. (2008) designed UbiFit, an activity-tracking device that synced with an application for mobile phones. The mobile phone application included setting the screen’s wallpaper to a “glanceable display” that summarised weekly activity and goal achievement through the metaphor of a growing garden. In a three-month field trial with 28 participants, 25 participants indicated that they would want the glanceable display (Consolvo, Klasnja, et al., 2008). In the winter holiday season, which is typically accompanied by decreased physical activity, participants with the glanceable display, on average, maintained their activity level while those without the glanceable display decreased their amount of physical activity. The study indicated that the progress tracking display helped participants maintain awareness of their activity level and provided motivation to meet goals.

These studies suggest a beneficial effect of automatic tracking of exercise information on activity levels.

2.3.4 Encouragement and Positive Reinforcement

Various forms of positive feedback and encouragement are used throughout the above technologies to support physical activity. Each of the virtual coaches in Asselin et al. (2005), Ruttkay and Welbergen (2008), and Buttissi (2006) provided verbal positive reinforcement or encouragement with statements such as Asselin et al’s (2005) “Good job” and “Keep it up”. Lin et al.’s (2006) Fish ‘n’ Steps provided positive reinforcement through the happiness and growth of each participant’s virtual fish. This positive reinforcement was an effective motivator for a significant number of participants who formed a certain emotional attachment to their fish. However, the game’s punishment, a sad fish, had limited effect on motivation as some participants chose not to look at their fish when they knew it would be sad. Based on the reaction to punishment in Fish ‘n’ Steps (J. J. Lin et al., 2006) and other persuasive technologies, Consolvo, Klasnja et al. (2008) chose to include only positive reinforcement in UbiFit. This positive reinforcement took the form of flower and butterfly ‘rewards’ for completing physical activities. In a three-week field trial with 12 participants, users found the garden rewards motivating, often surprisingly so (Consolvo, McDonald, et al., 2008). Participants also gave positive feedback regarding these rewards in Consolvo, Klasnja et al.’s (2008) larger three-month field trial with 28 participants; however, participants also indicated that they would like the option of metaphors other than the garden and the ability to change metaphors to avoid boredom.

Encouragement/positive feedback can take many forms and appears to have a positive effect on users’ motivation for physical activity. Importantly, negative feedback may not be an effective means of increasing exercise, and boredom may limit the long-term efficacy of unchanging virtual rewards systems. As in other areas, personal preferences should be accommodated when possible to ensure effective delivery of these forms of motivation and to improve engagement with the technology.
Although research on persuasive technology for supporting exercise remains limited, early evaluations indicate that these interactive systems may be an effective approach for increasing people’s physical activity. Research in this area suggests multiple means of exercise support, including exercise monitoring, goal/progress tracking, and encouragement/positive feedback, that could benefit people with chronic pain.

2.4 Implications of Research

In order to help patients establish and maintain self-management routines, technology cannot only teach management skills over a finite period; it must facilitate long-term behaviour change by addressing motivation and self-efficacy. Self-motivation has been reported to predict patient adherence to physiotherapy rehabilitation programmes (Bassett, 2003). Efficacy beliefs refer to beliefs regarding one’s ability to produce desired results and forestall detrimental results; as such, self-efficacy plays a central role in the self-regulation of motivation (Bandura, 2001). Technology may be able to increase home exercise adherence by providing an alternative to relying on a physiotherapist for motivation. By providing exercise monitoring, progress tracking, positive feedback, and encouragement to perform home exercises, i.e. the forms of support shown to improve adherence when provided by physiotherapists, technology could potentially improve exercise compliance by promoting self-motivation. Progress tracking and associated goal setting are known to effectively increase self-motivation. Social cognitive theory (Bandura, 2001) explains that goals motivate behaviour by activating self-evaluation in the context of personal standards. Setting personal standards to guide self-evaluation enables people to create incentives that drive behaviour towards goals. By engaging in behaviours that meet their personal standards, people feel satisfaction, pride, self-worth, and increased self-efficacy (Bandura, 1977, 2001). Encouragement in the form of verbal persuasion can also help promote self-efficacy (Bandura, 1977). Thus, technology may be able to provide the guidance, encouragement/positive feedback, and behaviour monitoring that help build self-efficacy and self-motivation for the exercise component of pain management.

Guidance, encouragement/positive feedback, and behaviour monitoring have been found promising when incorporated into persuasive technology aimed at increasing physical activity (Consolvo, Klasnja, et al., 2008; Lin et al., 2006). However, research on technology-based delivery of these mechanisms for encouraging physical activity in the chronic pain population is limited. Furthermore, current exercise support technologies do not address the unique barriers to physical activity with chronic pain, such as pain-related fear of movement/(re)injury. Drawing from e-health and persuasive design research, and the user requirements identified by O’Connor (2008), the present study explored the ways in which a novel technology could support regular physical activity in people with chronic pain, including how supportive functions should adjust to meet the needs associated with different states of behaviour and affect.
CHAPTER 3. METHODS

The present study explored user needs for an interactive technology to support people with chronic musculoskeletal pain perform regular physical activity after completing a structured treatment programme. Studies of assistive technology and proposed methodologies for the design of e-health systems have identified consideration of user expectations and needs as a key step in development (Dabbs et al., 2009; De Rouck, Jacobs, & Leys, 2008; Wessels, Dijcks, Soede, Gelderblom, & De Witte, 2003; Årsand & Demiris, 2008). As O’Connor’s (2008) investigation provided an understanding of the current behaviours of people with chronic musculoskeletal pain and the challenges to self-management, the present study was able to begin exploring specific needs for exercise along with potential technology-based solutions derived from previous research. Recommended methods to elicit user expectations and requirements include interviews with users and other key informants and questionnaires (De Rouck et al., 2008; Årsand & Demiris, 2008). The present study therefore explored user expectations and needs through: (1) interviews with people with chronic musculoskeletal pain and physiotherapists experienced with chronic pain treatment, and (2) a questionnaire for people with chronic musculoskeletal pain. Interviews with more than one type of stakeholder and the use of more than one data collection method provided data triangulation, which helps validate results and minimises the methodological weakness of obtaining qualitative data from a relatively small number of observations (Adams & Cox, 2008).

3.1 Interviews

Semi-structured interviews were conducted to explore the ways an interactive technology could best support physical activity in people with chronic musculoskeletal pain. Semi-structured interviews ensure that the same topics are covered with each interviewee while providing the flexibility to explore interesting areas (Preece, Rogers, & Sharp, 2002). In accordance with the semi-structured interview approach, questions were used to guide the interviews (see Appendix 1), but interesting leads were followed as they arose during the interview. Interviews were analysed using a grounded theory approach.

3.1.1 Participants

Individuals with chronic musculoskeletal pain and physiotherapists with experience treating chronic pain were recruited through multiple channels: (1) people with chronic pain and pain professionals affiliated with the project were contacted individually by email; (2) contacts formed through questionnaire distribution who showed interest in the study were contacted individually by email; (3) an email was sent to all post-graduate students enrolled in either Human Computer Interaction with Ergonomics or Computer Science at University College London (UCL); and (4) an announcement was posted on the UCL participant recruiting system Sona, which is open to anyone who wishes to register. Participants could not be recruited through National Health Service (NHS) channels, as the author did not obtain the research passport required by the NHS. Recruiting messages invited recipients to participate in an approximately 30-minute interview, in-person or on the phone, regarding how an interactive technology could best support people with chronic musculoskeletal pain in doing physical activity.
3.1.2 Ethics

Questions prepared for the semi-structured interviews were reviewed by a senior clinical psychologist with experience working with chronic pain patients in an effort to minimise the likelihood of questions causing distress to participants with chronic pain. Informed consent was received from all participants not affiliated with the research project (see Appendix 2 for information sheet and consent form).

3.1.3 Materials

All interviews were recorded using the software GarageBand '08 (Apple Inc., 2002-2007) and played back for transcription using ExpressScribe (NHC Software). Data analysis was conducted using MAXQDA 10 (VERBI GmbH, 1995-2010).

3.1.4 Analysis

All interviews were transcribed by the author. Interview transcripts were analysed using grounded theory, which is a method of deriving theoretical constructs from the analysis of qualitative data (Corbin & Strauss, 2008). Corbin and Strauss (2008) describe qualitative analysis as “a process of examining and interpreting data in order to elicit meaning, gain understanding, and develop empirical knowledge” (p. 1). As recommended, analysis of early interviews was used to guide later interviews such that areas of interest could be investigated in more depth (Corbin & Strauss, 2008). Corbin and Strauss (2008) note that ongoing analysis throughout data collection has the additional benefit of enabling the researcher to “listen and observe in more sensitive ways” (p. 57).

Data analysis of each transcript followed recommendations by Corbin and Strauss (2008), beginning with reading the transcript and followed by coding the data for concepts. Corbin and Strauss (2008) describe this analysis as “a process of generating, developing, and verifying concepts” (p. 57). Thus, as recommended, memos were used to elaborate and reflect upon codes and selections of raw data to facilitate the process of analysis. Coding comprised both open and axial coding, which work together during the identification and elaboration of concepts. Corbin and Strauss (2008) define open coding as “breaking data apart and delineating concepts to stand for blocks of raw data [as well as] qualifying those concepts in terms of their properties and dimensions” (p. 195) and axial coding as “crosscutting or relating concepts to each other” (p. 195). As analysis progressed, axial coding led to the identification of several high-level concepts, which Corbin and Strauss (2008) refer to as themes. These themes were used to organise and relate lower-level concepts. Appendix 3 presents samples of coded interview transcripts.

3.2 Questionnaire

A questionnaire was used to target a larger group of people with chronic musculoskeletal pain in order to validate and expand upon data collected in interviews (see Appendix 4 for the questionnaire). The questionnaire was developed based on concepts identified in early interviews and was distributed online. Internet based questionnaires are an effective method of research, especially for targeting specific groups of participants such as those with shared interests or a shared health condition (Kraut et al., 2004). The Board of Scientific Affairs’ Advisory Group on the Conduct
of Research on the Internet advises researchers to pre-test instructions and questions due to the difficulties of monitoring and intervening in online data collection (Kraut et al., 2004). The questionnaire was therefore pre-tested with five individuals to ensure clarity.

3.2.1 Participants

People with chronic musculoskeletal pain were recruited through online chronic pain support sites, including websites, Facebook groups, and Twitter accounts. As the current project is targeting the UK chronic pain population, only support groups/websites serving UK communities were contacted.

3.2.2 Ethics

In an effort to minimise the likelihood of questions causing distress to participants, the questionnaire was reviewed by a senior clinical psychologist with experience working with chronic pain patients, as well as two care-givers of a patient with chronic pain.

The questionnaire’s landing page (see Appendix 4) contained information about the research and advised participants that they could exit the survey at any time. Participants were informed that they provided their consent for participation upon clicking ‘Next’ to reach the first page of the questionnaire.

3.2.3 Materials

The questionnaire was created and hosted with Opinio (ObjectPlanet, 1998-2011), an online survey tool. Videos embedded in the questionnaire were hosted on Vimeo (Vimeo, LLC, 2011). SPSS 16.0 (SPSS Inc., 1989-2007) was used to perform all statistical analyses.

3.2.4 Analysis

Descriptive statistics were used to analyse the questionnaire results. A Friedman’s Test was used to compare ratings of four example avatars.

---

1 The Advisory Group on Conducting Research on the Internet was established in 2001 by the Board of Scientific Affairs, which is the primary advisory body to the American Psychological Association’s Science Directorate.
CHAPTER 4. RESULTS: INTERVIEWS

This chapter presents the concepts that emerged from participant interviews. Interviews were conducted with seven people with chronic musculoskeletal pain and four physiotherapists. Interview duration ranged from 26 to 51 minutes. Although the number of participants was limited due to the author’s restricted recruiting options, some concepts approached saturation, which is the point at which categories have been developed in terms of their properties and dimensions and indicates the completion point of data collection (Corbin & Strauss, 2008). Several concepts that required further investigation are discussed in Chapter 6 under future research. Several participants have been active in the chronic pain community, allowing us to benefit from their knowledge of their own experience as well as that of others with chronic pain. Both in-person and phone interviews were conducted, depending on participant preference. Participant information is presented in Tables 1 and 2. Each participant was assigned an ID; participants with chronic pain are referred to as P# while physiotherapist participants are referred to as PT# where # indicates the reference number. All participants had some level of familiarity with video games like those of the Xbox Kinect or Nintendo Wii. To ensure a common point of reference, participants were shown a movie clip of a person playing Your Shape: Fitness Evolved (Ubisoft Entertainment, 2010) on the Xbox Kinect.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Pain Duration (years)</th>
<th>Pain Community Involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Female</td>
<td>52</td>
<td>33</td>
<td>Patient advocacy</td>
</tr>
<tr>
<td>P2</td>
<td>Female</td>
<td>53</td>
<td>3 (has had little to no pain for the last 18 years by managing her condition with exercises)</td>
<td>Patient advocacy; former chief executive of a chronic pain charity</td>
</tr>
<tr>
<td>P3</td>
<td>Male</td>
<td>57</td>
<td>40</td>
<td>Patient advocacy; training of healthcare professionals</td>
</tr>
<tr>
<td>P4</td>
<td>Female</td>
<td>72</td>
<td>35</td>
<td>Established patient support website</td>
</tr>
<tr>
<td>P5</td>
<td>Female</td>
<td>50</td>
<td>5</td>
<td>None</td>
</tr>
<tr>
<td>P6</td>
<td>Male</td>
<td>35</td>
<td>3</td>
<td>None</td>
</tr>
<tr>
<td>P7</td>
<td>Female</td>
<td>28</td>
<td>17</td>
<td>Training to become an Alexander Technique teacher</td>
</tr>
</tbody>
</table>

Table 1. Profile of interviewed participants with chronic pain
The analysis of interview transcripts led to identification of five primary themes: pain management approach, personalisation, supportive functions, encouraging adherence, and visual representations. Table 3 summarises the themes and concepts that emerged in the interviews. Note that concepts were related and sometimes overlapped; as such, a number of concepts applied to more than one theme. For simplicity, concepts were assigned to one main theme, but some concepts will appear in the results in relation to more than one theme.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain Management Approach</td>
<td>• Correct Posture</td>
</tr>
<tr>
<td></td>
<td>• Body Awareness</td>
</tr>
<tr>
<td></td>
<td>• Pacing</td>
</tr>
<tr>
<td></td>
<td>• Cognition &amp; Affect</td>
</tr>
<tr>
<td>Personalisation</td>
<td>• Education</td>
</tr>
<tr>
<td></td>
<td>• Detecting Physical Problems</td>
</tr>
<tr>
<td></td>
<td>• Tailored Exercise Programme</td>
</tr>
<tr>
<td></td>
<td>• Demonstrating Exercises</td>
</tr>
<tr>
<td></td>
<td>• Correcting Posture</td>
</tr>
<tr>
<td></td>
<td>• Exercise Monitoring</td>
</tr>
<tr>
<td></td>
<td>• Information Tracking</td>
</tr>
<tr>
<td>Functions</td>
<td>• Managing Expectations/Goals</td>
</tr>
<tr>
<td></td>
<td>• Managing Setbacks/Flare-ups</td>
</tr>
<tr>
<td></td>
<td>• Forming/Maintaining Habit</td>
</tr>
<tr>
<td></td>
<td>• Encouragement/Positivity</td>
</tr>
<tr>
<td></td>
<td>• Engagement</td>
</tr>
<tr>
<td>Encouraging Adherence</td>
<td>• Body Image</td>
</tr>
<tr>
<td></td>
<td>• Virtual Coach Appearance</td>
</tr>
<tr>
<td></td>
<td>• Avatar Appearance</td>
</tr>
<tr>
<td></td>
<td>• Progress Visualisation</td>
</tr>
</tbody>
</table>

Table 2. Profile of interviewed physiotherapists

Table 3. Themes and concepts identified in interviews
The remainder of this chapter explains each theme and its associated concepts, which are illustrated with participants’ quotes. For additional quotes exemplifying each concept, see Appendix 5.

4.1 Pain Management Approach

The participant’s pain management approach was an overarching theme that influenced most concepts. The primary approaches that arose in the interviews were: (1) physiotherapy based on a mainly musculoskeletal approach, (2) multidisciplinary pain management, and (3) Alexander Technique. Even within the category of multidisciplinary pain management, various philosophies were apparent among the participants. While some concepts of pain management overlapped between these different approaches, other concepts reflected a range of beliefs.

4.1.1 Correct Posture

The degree of focus on ‘correct posture’ in static positions and while moving was the primary contrast between the different management approaches. The majority of participants believed that correct postures exists and that pain management includes trying to work towards maintaining correct postures during everyday activities and exercise. The main reasons for striving for correct postures were:

0) to correct learned habits of abnormal movement:

PT2: The machine or the equipment [should] be able to pick up on abnormality of movements and try to advise the person to move differently in order to correct them.

1) to obtain the maximum benefit from exercises:

P5: And it would also confirm that I was doing it correctly because that’s a big issue with the exercises I’ve been given that if you do them wrong you’re not going to get any benefit.

2) to prevent injury during exercise, a concern reflecting the pain-related fear that is often found in people with chronic pain:

P4: [If you’re not doing the exercise correctly] you could be hurting yourself.

In general, the emphasis on correct movements was associated with the approaches of multidisciplinary PMPs and physiotherapy with a musculoskeletal orientation. At the opposite end of the spectrum was PT4, who was trained in a multidisciplinary PMP approach emphasising that there are no correct postures and that people with chronic pain must focus on moving in any way they can. Between the above perspectives was the approach described by P7, who found help for her pain through the Alexander Technique and has been training to become an Alexander teacher. From her perspective, there are indeed correct postures, but these can vary between individuals. The Alexander Technique teaches pupils not to actively try to attain a particular posture because this causes muscular tension.
The core belief regarding whether correct posture should guide pain management influenced the dimensions that arose in many other concepts.

4.1.2 Body Awareness

A concept closely related to that of learning correct postures and movements was the need to build awareness of one’s body and patterns of movement. This concept arose in terms of:

(1) recognising maladaptive postures:

PT2: First, you can make them aware of it. [...] Often people have been moving in an abnormal pattern for some time. [...] Now their proprioception has adapted so much that they are totally unaware of it.

(2) gaining awareness of muscle activity:

P6: I may not be aware that my muscles are starting to be stiff until I realise I have pain, and then in that it is more difficult to relieve the pain.

For many participants, improving body awareness was considered a key step in learning to break unhelpful movement patterns and enabling the body to adopt correct postures.

P7: It’s really that you become much more kind of literate and tuned in to your body in the environment. [...] And you start to notice ‘Oh my head is forward from my body. Could I let that go?’

PT1: [...] constantly giving feedback [and] getting them to pick up on errors in how they move themselves.

4.1.3 Pacing

The concept of pacing arose in all pain management approaches except for Alexander Technique. The two dimensions of pacing described were:

(1) gradually increasing activity or exercises over time:

PT4: I guess one of the principles that we encourage patients to take on board most with pain management is pacing activity. [...] somebody might determine what their baseline for sitting is, so they might need something to remind them to move after say 10 minutes or 15 or 20.

(2) maintaining a relatively constant activity level from day to day:

P2: One of the key things that happens is, with chronic pain, is over-activity under-activity cycles. [...] So there should be encouragement to try and maintain a fairly regular level of exercise.
While participants generally agreed that decreasing the level of activity was acceptable for days with increased pain, participants disagreed with whether activity should increase on a day with less pain:

P4: If you were having a good day, there again you don’t want to overdo it [...] cause the next day may not be quite so good.

PT2: We’re getting into a whole realm here about the validity of pacing, which is very difficult in the literature. And there’s a lot of people who do do things when they feel they’re having a good day.

4.1.4 Cognition & Affect

The concept of addressing maladaptive cognitions and negative affect arose, to varying degrees, in every treatment approach. Participants described the need to address cognitive biases such as catastrophising and the belief that pain indicates damage, as well as the depression, fear, and anxiety that often occur in people with chronic pain.

P6: [...] you can do the exercise and physically you are better, but probably in your mind you are not that well because [...] still you are very far from doing probably what most of the people do [...] or what you were able to do before.

PT2: [...] trying to stop people from this catastrophic thinking that leads to their low mood – they have a bad day but the way in which they frame that bad day, the way in which they interpret it, makes a big difference to whether they actually start to, if you would like, fail to use their self-management skills.

The multidisciplinary PMP approach placed the greatest emphasis on the importance of addressing cognitive biases and negative affects in the management of chronic pain, which is largely achieved through incorporating cognitive behavioural therapy into treatment.

4.2 Personalisation

The theme of personalising the technology’s functions and options arose throughout the interviews. Participants emphasised the importance of personalisation in terms of types of pain, needs, abilities, goals, and preferences. This theme permeates all other concepts either implicitly or explicitly, and therefore will be discussed as appropriate throughout the remaining concepts.

4.3 Supportive Functions

Participants identified many functions that could support the physical activity component of their pain management. The recurring concepts were education, detecting movement problems, tailored exercises, exercise demonstration, posture correction, exercise monitoring, and information tracking.
4.3.1 Education

Several participants noted the importance of including instructions and reminders about how to self-manage in the technology programme.

P3: […] they need to know the theory as well, like pacing, setting baselines, and things like that. So sometimes, if they wanted to, if they ‘well, what is this baseline business? I can’t remember how that really works’. If there was like a short movie of what a baseline is.

4.3.2 Detecting Physical Problems

Some participants were eager for the technology to be able to detect physical problems such as muscular tension and movement abnormalities.

P6: So probably if the machine could let me know when [my muscle stiffness has] reached a threshold from which that point it starts to appear the pain [sic].

PT2: […] the ability of the machine or the equipment to be able to pick up on abnormality of movements, and try to advise the person to move differently in order to correct them.

4.3.3 Tailored Exercise Programme

Most participants expressed the need for exercise programmes that are tailored to the user’s particular needs. This concept arose both in the context of long-term exercise programmes and short-term changes to the exercise programme. The factors that arose as important to determining longer-term exercise programmes were type of pain, abilities, pacing, and functional goals. In the context of short-term changes to the exercise programme, participants wanted to know that the exercises were adjusted to their present physical state, including level of pain.

P6: So for example […] if your muscles are very tight, or you feel uncomfortable, it is possible for the machine to to suggest the exercises to loose [sic] the muscles.

P2: [When the user has more pain] I think there would be concerns about safety and the possibility of harm and making things worse so reassurance and making it clear that whatever level of pain is recognised in the, in what you’re supposed to do.

P2’s comments, along with others, suggested that pain-related fear may increase during periods of heightened pain and that the technology would need to address these fears.

Several participants emphasised that tailoring exercise programmes according to personal goals and the user’s pain and mood should be a collaborative process between the technology and the user. Participants emphasised the importance of building self-management skills such that people with chronic pain have the knowledge and confidence to make the best decisions for themselves, a process supported in treatment through collaborative problem-solving with the professional.
Many participants saw the technology as a way to continue providing guidance in self-assessment of one’s physical and emotional state and in decision-making.

P3: So really helping the person to do their own problem-solving, to recognise how they’re feeling and to think about how they should maybe adjust their goals for that day or what they can do to make themselves feel better.

In response to questions regarding the helpfulness of the technology being able to recognise the user’s pain level and mood, many participants were sceptical and preferred that the technology facilitate self-assessment instead.

P1: I think probably the person who knows best how they’re feeling is the patient. But you then get all that psychological babble going on in your head that can very easily confuse the messages. So maybe if the technology is able to clear those pathways and say, ‘okay, hang on a minute. Let’s just think clearly about how you are today’. A sort of help – I would think the technology could be used to help the patient self-assess.

4.3.4 Exercise Demonstration

Most participants thought the inclusion of a figure (e.g. a virtual coach) to demonstrate the exercises would be helpful.

P3: When I go down to the gym, and I do, I watch other people, how they do things on the machines and stuff like that. But to me, say for example if I was having a bad day, and I, or the weather was crap, and I wanted to exercise, I can do it at home with my home coach.

P6: So it would be brilliant to have a coach that you can follow.

4.3.5 Posture Correction

Obtaining corrective feedback from the technology was a critical function for almost all participants due to concerns with performing exercises correctly and avoiding injury.

P1: So you need to get feedback that shows that you’ve done the exercise correctly.

4.3.6 Exercise Monitoring

Participants identified several types of feedback they would find helpful during exercise, including seeing their own movements, a count of repetitions, a timer for exercises such as stretching, the extent of movement, cues regarding what area of the body to focus on during a particular exercise, and information about previous performance and progress.

PT3: […] start with very very small movements to the side, sort of tick-tock movements, and then you know you would tell them, ‘look you’re
moving 10 degrees. That’s brilliant. You only moved 5 degrees yesterday. That’s great.

The feedback regarding users’ movements will be discussed further under the concept of avatar appearance.

4.3.7 Information Tracking

Almost all participants spoke about the importance of tracking performance as a way of seeing progress.

PT1: I think that if you’re ever able to measure improvement then that’s a really motivating factor. Because with any sort of chronic condition when you start to move about or continue to move about, the progress is always very slow and it’s almost non-noticeable.

Several participants also mentioned the importance of building awareness of one’s daily level of activity. These participants suggested two methods of incorporating activity done without the technology: using a tracking device, such as a pedometer, that could upload daily activity to the main technology, and allowing users to enter specific activities into the main technology’s tracking interface.

P3: I think a lot of people with pain they’re either under-doers or over-doers. So something where – and that’s why I use a pedometer cause that tells me how active I’ve been today or how inactive I’ve been. [...] I always recommend this to patients.

PT2: So I think it would be helpful if you have things outside of the game as well. So when they logged on they, you know, their trainer could say, ‘well, in the last week you’ve managed to walk some 2.5 km, [...] well done, this compares with the previous week…’ whatever. Those sorts of things would be helpful because I think people often don’t realise how far they are moving and walking.

One area of disagreement was the usefulness of tracking pain. Some participants found pain tracking useful for the positive reinforcement of seeing pain levels decrease or the possibility of identifying activities that exacerbated pain. Other participants noted that tracking pain would not be helpful for individuals whose pain was not decreasing, for whom the focus must be on increasing/maintaining functional ability.

PT4: [...] our approach here is not to stop the pain; it’s more about encouraging them to focus on what they can do and build up their activity and stuff like that. [...] if it’s constantly asking them to check on their pain they may notice that actually their pain’s not changing. That can be hugely demotivating.

There was a general agreement that the helpfulness of pain tracking depends on each person, both on the particular condition and personality.
P7: Just recently I started doing pain ratings and that was quite useful actually. [...] There are people I think it would almost exacerbate pain by looking for it and concentrating on it and being anxious about it. It would be very personal whether it would be helpful or not.

4.4 Encouraging Adherence

A number of concepts emerged relating to strategies to encourage exercise adherence. The concepts revolved around the complexity of maintaining motivation, especially in the face of increased pain or poor mood. The concepts that arose in this theme were managing expectations, managing flare-ups/setbacks, forming/maintaining habit, encouragement/positivity, and engagement. In addition, information tracking, particularly tracking progress towards goals, arose as an important motivator for exercise, as discussed in section 4.1.3.

4.4.1 Managing Expectations/Goals

Having appropriate expectations, both for individual sessions and over the long-term, emerged as an important factor to successfully continuing self-management behaviours. For each session, people with chronic pain need to be aware of how they are feeling and adjust their expectations accordingly to avoid the disappointment of not meeting goals that were unrealistic for that day.

P1: I would imagine that it would be useful [to start with] saying ‘well before we start your programme why don’t you have a think about how you’re feeling today. Have you thought about what you’re going to try to achieve from today’s session?’ Rather than them getting into the session and then finding that they can’t do it because they’re too tired or it’s too difficult because that’s very demotivating.

Over the long-term, participants stressed that people cannot necessarily expect their pain to decrease and that they must view pain flare-ups as a natural part of chronic pain that are expected, rather than as a failure of their pain management.

4.4.2 Managing Flare-ups/Setbacks

Participants identified flare-ups in pain and other setbacks, such as a lapse in exercising during illness, as major obstacles to maintaining self-management behaviours due to the psychological and physical toll they take on patients.

P1: And I think dealing with setbacks is one of the most complex issues. [...] Because what happens if you have a setback for whatever reason, it’s very easy to assume that you’re going to go all the way back to where you started.

PT2: [...] the corrosive effect of repeated flare-ups and also the corrosive effect of the fact that people then feel that they’re not making progress, so they don’t have someone there to help reevaluate how much progress they’ve made. I think that often can mean that people start to slide back down into depression, catastrophic thinking, and start to restrict their activities.
To support people through these flare-ups and setbacks, participants emphasised the need to manage expectations, as previously discussed, and the need for cognitive reframing (a cognitive behavioural therapy technique for addressing negative, distorted thoughts (Eccleston, 2001), reassurance, encouragement, doing relaxation exercises, and continuing some level of activity.

PT2: [...] they could use an avatar to go through some simple questions, some simple reassurance, and then try to get them back on line. [...] And to get people to re-evaluate – cause often what happens when people have a flare-up, they can go to a whole track of negative thinking, and if we can just get people to a point where we can do cognitive reframing [...] to get people to view this as just something that was expected.

PT4: [It] might be useful to remind them that they’ve had flare-ups before and they’ve managed to work through them. It might also be useful to remind them that [...] it’s okay to reduce that amount [of activity]. That doesn’t mean that it’s worthless, but it’s actually going to help them get through this flare-up as quickly as possible.

4.4.3 Forming/Maintaining Habit

Several participants discussed the importance of making exercise habitual for continued adherence to the exercise programme.

P5: I mean it’s about building up the habit and [...] even just kind of doing a chart showing the days you missed and the ones you hit to kind of encourage you to fill in more of the holes.

PT2: I think this is just a little bit too often what people do is that when they get a flare-up they get out of the pattern and then they don’t get back into it again. [...] they become very avoidant during those periods and it’s a good idea to do something rather than do nothing.

4.4.4 Encouragement/Positivity

For almost all participants, encouragement and focussing on the positive were critical factors in maintaining motivation to continue self-management physical activity. Forms of encouragement included verbal positive reinforcement, reminders of why exercises are helpful, and reminders of progress.

P2: [...] something that reminds you of the rewards to be gained or the reasons why you’re doing it and you know the sort of encouragement and [...] perhaps reflecting back on what you’ve achieved so far as a way of encouraging as well.

Focusing on the positive was also important, especially in the context of corrective feedback and managing flare-ups/setbacks.

P2: Well encouragement is the key thing. [...] So I suppose it might be something like, ‘that was great maybe you were putting a bit too much weight on your...’
PT3: [In the case of a flare-up] I think just to keep pointing out where on the journey they are so, you know, ‘this is still a move forward for you. The very fact you’re doing these daily movements is a move forward for you’. [And] saying that actually changing the grade of the exercise they’re doing is all of the time building their awareness about how to manage an active life within their chronic pain scenario.

Participants noted that different people respond to different forms of encouragement, and that some users may not want any type of encouragement from the technology.

PT3: So that perhaps they get a choice of particularly encouraging phases that they would like to choose because a physiotherapist working with somebody you very soon can tell […] whether if you say to them ‘now breathe, push through, push through’ that’s going to help them or if you just need to literally say to them all of the time ‘you’re doing great, you’re doing great, you’re doing great’.

4.4.5 Engagement

The use of technology in self-management was seen by some participants as an opportunity to improve adherence through engagement with the technology itself.

P7: I know there are people whose eyes would light up at the idea of a piece of technology and that would motivate them in itself.

Both a virtual coach and avatar representation of the user were seen as possible ways to increase engagement with the technology.

4.5 Visual Representations

Preferences for the visual representations of the virtual coach, the user’s avatar, and the information tracking were influenced by several factors including body image, what information was considered helpful, and what could be motivating. As with the other themes, personalisation and choice frequently emerged throughout the following concepts as a way to accommodate individual’s various preferences. The concepts discussed in this section are body image, virtual coach appearance, avatar appearance, and progress visualisation.

4.5.1 Body Image

The concept of body image arose in almost every interview. Participants noted that people with chronic pain often have low opinions of their bodies.

PT2: I think often people have a very poor image of themselves to begin with.

This was an important factor in determining the appearance of a virtual coach and the avatar representation of the user.
4.5.2 Virtual Coach Appearance

Many participants emphasised that the virtual coach should not have the ‘ideal’ body. This was important both to avoid making the user feel bad about his/her own body and to allow the user to relate to the coach.

P3: […] if your buddy wasn’t a big fit, you know like a Chip ‘n’ Dale type, or a young slim woman, but someone who was a little bit overweight, even someone whose had pain himself.

P4: It would have to be somebody who wasn’t scarily fit. […] Cause I find that with a lot of exercise videos […] you get some super super fit person that’s doing things that you couldn’t possibly ever achieve or really aim to be like, which is rather off-putting.

Preferences for the appearance of the virtual coach ranged from making it slightly overweight and middle-aged to simply having a mannequin-type representation.

4.5.3 User Avatar Appearance

Body image was also a critical factor in participants’ preferences for the appearance of their own onscreen representation. Almost all the participants with pain were clear in not wanting to see a realistic, mirror-like image of themselves.

P1: Well, I wouldn’t want to see a representation of myself any day, if it was an accurate representation […] It’s bad enough, you know, when you look at yourself in the mirror in a changing room and you think, God, do I really look like that? […] So I think I would keep it on the sort of anonymous female shape / male shape of sort of non-descript size.

While the majority of participants with pain preferred an abstract avatar, some participants with clinical experience emphasised the importance of seeing a realistic body representation.

PT3: I think the ideal is to see a reproduction of yourself really. […] I can print off exercises for people with generic line drawings and if I produce those sort of exercises for people I don’t get the same level of compliance as if I take photographs of people and then put them into my computer and, say, you know I’ve taken a photo of them bending sideways and then I feed that in.

In addition to concerns related to body image, participants also emphasised the need for clarity so they could understand how they were moving and possibly notice improvements. Several participants mentioned the possible addition of cues emphasising how to correct their movements or what body areas to focus on.

P5: […] have an overlay to try and get your foot into the right position. […] So it would say kind of ‘move to the left’ and you’d have the outline of where you need to try and get your shoulder to that position.
4.5.4 Progress Visualisation

Participants were asked to consider concrete progress visualisations, such as graphs or charts, versus abstract visualisations, such as a growing garden. While opinions greatly varied, what emerged was the importance of allowing users to choose a representation that is personally motivating and rewarding.

P1: I mean you could have a little bar graph at the end of you session [...] to show progression.

P2: I think something quite playful would be quite nice. [...] something that’s linked to their own lifestyle and things that are important to them – their own hobbies. I think a garden would be nice, that’s the sort of thing that would appeal to me.

4.6 Summary

Grounded theory analysis of participant interviews identified five primary themes: pain management approach, personalisation, supportive functions, encouraging adherence, and visual representations. The identified concepts indicated that supporting regular exercise in chronic pain management requires addressing users’ physical, cognitive, and emotional needs. Thus, a technology would need to not only suggest, monitor, and track exercises, but also address fears regarding the safety of exercises, body image sensitivities, and the challenge of continuing some amount of physical activity during flare-ups and setbacks.
CHAPTER 5. RESULTS: QUESTIONNAIRE

A questionnaire was distributed to people with chronic pain to validate and expand upon concepts identified in the first five interviews: P1-P3 and PT1-PT2. Sixty-six people completed the questionnaire. After excluding respondents with pain other than musculoskeletal pain, 58 respondents remained. An additional five participants who completed at least 75% of the questionnaire were included in analysis. Therefore, most analyses included a total of 63 participants (see Table 4 for the profile of participants). The caption for each table/figure indicates the number of participants included in that analysis.

<table>
<thead>
<tr>
<th></th>
<th>Mean or Percent</th>
<th>Standard Deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>49 years</td>
<td>13 years</td>
<td>20-74 years</td>
</tr>
<tr>
<td>Female</td>
<td>78%</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pain duration</td>
<td>12 years</td>
<td>8 years</td>
<td>1-35 years</td>
</tr>
<tr>
<td>Has been treated by a physiotherapist</td>
<td>91%</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Average pain rating (1 = no pain, 10 = extreme pain)</td>
<td>6.9</td>
<td>1.5</td>
<td>4-10</td>
</tr>
<tr>
<td>Peak pain rating for previous month (1 = no pain, 10 = extreme pain)</td>
<td>8.7</td>
<td>1.6</td>
<td>3-10</td>
</tr>
</tbody>
</table>

Table 4. Profile of questionnaire participants (number of participants = 63).

Most participants (76%) had some level of familiarity with video games like those on the Xbox Kinect or Nintendo Wii; 24% of respondents had no knowledge of these types of video games (see Table 5). To ensure a minimum level of familiarity with motion detecting technology, participants were shown a movie clip of a person playing Your Shape: Fitness Evolved (Ubisoft Entertainment, 2010) on the Xbox Kinect.

<table>
<thead>
<tr>
<th>Game Experience</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have never seen or heard about these game systems.</td>
<td>24%</td>
</tr>
<tr>
<td>I have watched others play Kinect and/or Wii games.</td>
<td>38%</td>
</tr>
<tr>
<td>I have played Kinect and/or Wii games on occasion.</td>
<td>32%</td>
</tr>
<tr>
<td>I have played Kinect and/or Wii games many times.</td>
<td>6%</td>
</tr>
</tbody>
</table>

Table 5. Participants’ experience with video games like those on the Xbox Kinect or Nintendo Wii (number of participants=63).

5.1 Supportive Functions

Participants who had been treated by a physiotherapist for their pain were asked to indicate the importance of supportive behaviours a physiotherapist could provide. These supportive behaviours were identified as key forms of support in early interviews. Confirming the interview results, all behaviours were rated, on average, just under very important: ‘demonstrates exercises’ (M: 4.39, SD: 1.0), ‘corrects your movements’ (M: 4.49, SD: 0.95), ‘encourages you to exercise’ (M: 4.42, SD: 0.94), ‘gives praise’ (M: 4.25, SD: 1.14), ‘sets exercise goals with you’ (M: 4.26, SD: 1.14),
and 'tracks your progress' (M: 4.58, SD: 0.94). Figure 2 depicts the distributions of these ratings.

Figure 2. Boxplot of participants’ ratings of the importance of their physiotherapist’s behaviours on a scale of 1 (not important at all) to 5 (very important). (Number of participants = 57)

Participants were then asked about possible supportive functions provided by technology. On a scale from 1 (not helpful) to 5 (very helpful), participants rated the helpfulness of seeing exercises demonstrated by a computer character as 4.08±1.17, on average. As shown in Figure 3, in addition to demonstrating exercises, most participants thought it would be helpful for a technology or virtual coach to correct the user’s movements (83%), encourage the user to exercise (60%), give praise (62%), and set exercise goals with the user (75%). The results corroborated views expressed in participant interviews.
Most respondents thought it would be helpful for the technology to be able to recognise and adapt the exercise programme and type of instruction to the user’s level of pain (94%) and mood (86%) (see Table 6).

<table>
<thead>
<tr>
<th>Functions</th>
<th>Response</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Would it be helpful for the technology to be able to recognise and adapt</td>
<td>Yes</td>
<td>94%</td>
</tr>
<tr>
<td>the exercise programme and type of instruction to your level of pain?</td>
<td>Not Sure</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2%</td>
</tr>
<tr>
<td>Would it be helpful for the technology to be able to recognise and adapt</td>
<td>Yes</td>
<td>86%</td>
</tr>
<tr>
<td>the exercise programme and type of instruction to your mood?</td>
<td>Not Sure</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 6. Participants’ selections for the helpfulness of the technology adjusting to the user’s pain or mood. Percents do not add to 100 due to rounding. (Number of participants = 63)

For sessions with lower pain, most participants wanted the technology or virtual coach to ‘remind me of my progress so far’ (81%), ‘show that it has recognised my level of pain’ (79%), and ‘remind me not to exercise too much’ (56%) (see Table 7). Fewer than half of participants wished the technology to ‘push me a little’ (39%) or to ‘be more upbeat’ (35%).
For days with higher pain levels, more than half of the participants wanted the technology/virtual coach to ‘show that it has recognised my level of pain’ (87%), ‘reassure me that the exercises for that session are safe’ (84%), ‘guide me in adjusting my goals for that day’s session’ (68%), ‘remind me of my progress so far’ (66%), ‘suggest different goals for that day’s session’ (61%), and ‘remind me of why exercising will help me’ (61%) (see Table 8). Very few participants wished to be ‘pushed’ while experiencing higher pain (11%). These results agree with interview results emphasising the need for encouragement, reassurance, and goal adjustment during flare-ups/setbacks.

Participants were also asked to select desired functions for when they had a positive mood versus when they had a negative mood. As shown in Table 9, for days when the user is in a positive mood, most participants wanted the technology/virtual coach to ‘show that it has recognised my mood’ (82%), ‘give a lot of encouragement’ (57%), and ‘push me a little’ (52%).
### Functions: Positive mood

<table>
<thead>
<tr>
<th>Function</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show that it has recognised my mood</td>
<td>82%</td>
</tr>
<tr>
<td>Give a lot of encouragement</td>
<td>57%</td>
</tr>
<tr>
<td>Push me a little</td>
<td>52%</td>
</tr>
<tr>
<td>Remind me not to exercise too much</td>
<td>47%</td>
</tr>
<tr>
<td>Be more upbeat</td>
<td>38%</td>
</tr>
<tr>
<td>Praise my good mood</td>
<td>33%</td>
</tr>
<tr>
<td>I am not sure</td>
<td>3%</td>
</tr>
<tr>
<td>Other</td>
<td>3%</td>
</tr>
</tbody>
</table>

**Table 9.** Participants’ selections for the technology or virtual coach’s functions for days when the participants are in a positive mood (Number of participants = 60)

As shown in Table 10, for days when the user is in a negative mood, most participants wanted the functions ‘show that it has recognised my mood’ (85%), ‘reassure me that bad days happen and it will get better’ (70%), ‘remind me of my progress so far’ (68%), ‘guide me in adjusting my goals for that day's session’ (67%), ‘give me a lot of encouragement’ (67%), ‘remind me of why exercising will help me’ (67%), ‘remind me that my emotions can affect my pain and my movements’ (67%), and ‘suggest different goals for that day's session’ (57%).

### Functions: Negative mood

<table>
<thead>
<tr>
<th>Function</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show that it has recognised my mood</td>
<td>85%</td>
</tr>
<tr>
<td>Reassure me that bad days happen and it will get better</td>
<td>70%</td>
</tr>
<tr>
<td>Remind me of my progress so far</td>
<td>68%</td>
</tr>
<tr>
<td>Guide me in adjusting my goals for that day's session</td>
<td>67%</td>
</tr>
<tr>
<td>Give me a lot of encouragement</td>
<td>67%</td>
</tr>
<tr>
<td>Remind me of why exercising will help me</td>
<td>67%</td>
</tr>
<tr>
<td>Remind me that my emotions can affect my pain and my movements</td>
<td>67%</td>
</tr>
<tr>
<td>Suggest different goals for that day's session</td>
<td>57%</td>
</tr>
<tr>
<td>Remind me not to exercise too much</td>
<td>43%</td>
</tr>
<tr>
<td>Empathise with how I am feeling</td>
<td>42%</td>
</tr>
<tr>
<td>Push me a little</td>
<td>25%</td>
</tr>
<tr>
<td>Be more serious</td>
<td>15%</td>
</tr>
<tr>
<td>I am not sure</td>
<td>3%</td>
</tr>
<tr>
<td>Other</td>
<td>3%</td>
</tr>
</tbody>
</table>

**Table 10.** Preferences for the technology or virtual coach’s functions for days when the participants are in a negative mood (Number of participants = 60)

Regarding information displayed during an exercise session, most participants wanted the functions identified as helpful in interviews: number of repetitions (78%), holding time for a stretch (75%), and goal for that exercise session (64%), extent of movement (54%), and information from your last exercise session (54%) (see Figure 4).
Figure 4. Participant selections for information displayed during exercises. (Number of participants = 59)

For the information tracked by the technology, again, most participants wanted the functions identified as helpful in interviews: exercise performance over a period (78%), goal for that exercise session (68%), number of repetitions (66%), replay of exercises with avatar (61%), holding time for a stretch (54%) (see Figure 5).

Figure 5. Participant preferences for information tracked by the technology. (Number of participants = 59)

Overall, respondents indicated the same preferences for supportive functions as identified in early interviews.
5.2 Visual Representations

Several questions addressed user preferences for visual representations of the user avatar and tracked information. Participants indicated that the technology showing their movements would be helpful with an average rating of 4.33±1.08 on a scale from 1 (not helpful) to 5 (very helpful). To give participants an idea of different types of avatar representations, they were shown four short clips of avatars representing a range of personalisation to the user (see Figure 6).

![Figure 6. Still frames from questionnaire movie clips showing different types of avatars. A (CamStudio motion capture), B-D (Your Shape: Fitness Evolved, Ubisoft Entertainment, 2010)](image)

Each avatar above was rated for how much it made the user want to move on a scale of 1 (does not make me want to move at all) to 5 (definitely makes me want to move). The Skeletal avatar inspired movement the most (M: 3.87, SD: 1.10), followed by the Purple avatar (M: 3.68, SD: 1.16), the Blue avatar (M: 3.50, SD: 1.24), and the Realistic avatar (M: 3.47, SD: 1.22). However, a Friedman Test, which was used because the data was not normally distributed, revealed no significant differences between the ratings (X² = 5.277, p > 0.05). Figure 7 depicts the distributions of avatar ratings.
Figure 7. Boxplot of participants’ rating of how much the avatar made them want to move on a scale of 1 (does not make me want to move at all) to 5 (definitely makes me want to move). Error bars represent standard deviation. (Number of participants = 59)

Although no significant differences appeared in ratings of the avatars, preferences did emerge when respondents were asked to select options for their avatar’s appearance (see Figure 8). Overall, respondents did not wish to see realistic depictions of themselves. Only 10% of respondents selected that they would like a ‘representation that looks just like me’. Possible reasons that this preference was not reflected in the avatar ratings are that participants did not imagine themselves depicted as the Realistic avatar or the quality of the movie clip did not adequately show the intended ‘mirror-image’ depiction. For overall avatar appearance, the most popular options were ‘standard representation that does not look like me’ (46%) and ‘cartoon representation that can look any way I choose’ (46%). Regarding the level of detail represented, participants were interested in an avatar showing what muscles were being used (73%) but not in seeing their facial expression (10%). Ten percent of respondents did not want to see any representation of themselves. Eight percent were unsure and 7% selected ‘other’. The preference for less personalised avatars agreed with feedback from interviews.
The questionnaire explained that user progress could be presented in various ways, such as in a concrete representation like a graph or an abstract representation like a garden for which the user could choose objects. Participants viewed an example of each type of progress visualisation (see Figure 9).

![Avatar appearance options](image)

**Figure 8.** Participants’ selections for the visual representation of users through an avatar. (Number of participants = 59)

![Example progress visualisations in questionnaire.](image)

**Figure 9.** Example progress visualisations in questionnaire. Left: garden. Right: graph.

As shown in Figure 10, the graph representation, selected by 38% of respondents, was more popular than the garden, selected by 17% of respondents. But the most popular option was to be able to see both types of representations (48%).
Figure 10. Participant selections of progress visualisation options. (Number of participants = 58)

These results agreed with the different personal preferences expressed in the interviews.

5.3 Summary

The questionnaire results indicated that users would like a technology to provide the same types of support as they value in a physiotherapist: exercise demonstration, corrective feedback, encouragement to exercise, praise, help with goal setting, and progress tracking. In addition, most participants wanted reassurance and encouragement during times of increased pain or negative mood. Preferences for visual representations indicated a need for less personalised avatar representations of the user and various types of representations of tracked information. Altogether, the questionnaire results corroborated the interview results.
CHAPTER 6. DISCUSSION

The present study investigated what feedback an interactive technology should provide to best support regular physical activity in chronic pain self-management. Five primary themes emerged from interviews with people with chronic musculoskeletal pain and physiotherapists experienced in treating chronic pain: treatment approach, personalisation, functions, encouraging adherence, and visual representations. The results of a questionnaire for people with chronic musculoskeletal pain corroborated many of the needs identified in interviews, especially that of personalisation. This chapter discusses the primary findings in the context of previous research and current technology, limitations of the current study, and future research.

6.1 Pain Management Approach

Participants’ experiences with different treatment approaches affected their perspective on user needs. Treatment approaches represented among interview participants included physiotherapy with a musculoskeletal focus, different types of multidisciplinary PMPs, and Alexander Technique. As the current treatment of choice recommended by the British Pain Society (2007), PMPs will be the focus of this discussion. Even with this narrowed treatment perspective, the main contention between treatment approaches that emerged in the interviews remains: whether users should strive to achieve ‘correct’ postures. There is not currently a consensus in the literature regarding whether physiotherapists should emphasise correct biomechanics (Bailey, Carleton, Vlaeyen, & Asmundson, 2010). Nevertheless, interview and questionnaire results indicated a prevailing concern with correct postures among people with chronic pain, with every interview participant with chronic pain expressing the need for guidance on correcting body postures and questionnaire respondents giving a high mean rating of importance (4.49, where 5 = very important) to receiving movement correction from physiotherapists. A technology for supporting chronic pain self-management would therefore need to explicitly address these concerns, either by providing corrective feedback, explaining why ‘correct’ movement is unimportant, or allowing the user or his/her healthcare professional to select a treatment approach for the programme.

6.2 Support for Physical Activity

The identified concepts regarding how an interactive technology can support physical activity in chronic pain self-management will be discussed in the context of pre-activity support, activity support, post-activity support, and overall engagement.

6.2.1 Pre-Activity Support

Planning pain management physical activity occurs in both long-term and short-term contexts. The interviews revealed that for long-term planning, people with chronic pain must set goals and the related pacing strategy based on their abilities and functional needs. Goal setting is a complex task often requiring a treating professional to help the patient identify measurable, achievable goals (Filoramo, 2007). As the focus of this study was the maintenance of regular physical activity following a
structured treatment programme, the particulars of goal setting will not be discussed here.

The present study indicated that in the short-term, people with chronic pain must be able to assess their present state, including their pain and energy, and adjust expectations and pacing accordingly. Interviewees emphasised the importance of patients building awareness of their physical and psychological state and determining the appropriate level of activity. The importance of these skills is supported by social cognitive theory, which emphasises the role of setting personal standards and self-evaluation in driving behaviour towards goals (Bandura, 2001). Considering that meeting personal standards fosters satisfaction and self-worth (Bandura, 2001), it follows that failing to achieve personal standards may result in feelings of lower self-worth, which could jeopardise motivation for exercise. As P1 explained, self-assessing and adjusting expectations is important because “getting into the session and then finding that they can’t do it because they’re too tired or it’s too difficult [is] very demotivating”. This lowered motivation may reflect lowered self-efficacy, which is critical in self-motivation and can decrease after experiencing failure (Bandura, 1977).

Self-efficacy plays an important role in successful chronic pain self-management (Jensen, Nielson, & Kerns, 2003). A main contributor to self-efficacy is mastery experiences, i.e. successes, which are especially important in early stages of behaviour change when failures can be particularly detrimental (Bandura, 1977). Therefore, people beginning to manage their pain independently may especially benefit from guidance in setting expectations, as this would increase the likelihood of experiencing success. Interviewees noted that many people with chronic pain could benefit from guidance in the process of self-assessment and setting expectations but emphasised that such guidance must be collaborative with the user. Similarly, focus groups with healthcare professionals and patients with chronic pain led Rosser et al. (2011) to conclude that their technology’s therapeutic feedback for chronic pain management must facilitate mindfulness of and reflection on activity, rather than proscriptive advice.

The ability to self-assess and set reasonable expectations, as well as apply cognitive therapeutic skills, is especially critical for the successful management of flare-ups and setbacks. Results suggested that people with chronic pain tend to avoid physical activity during flare-ups, a finding supported by previous research showing abnormal activity patterns including overall activity avoidance and cycling between under-activity during flare-ups and subsequent over-activity (McCracken & Samuel, 2007). Rosser et al. (2011) identified the importance of personalising the system’s content and feedback to the patient’s behaviour, e.g. activity pattern, and affective state. This concept of personalisation appeared throughout participant interviews, including with regards to pain level and mood. In the context of pre-activity support, personalisation applies to the guidance provided for users’ self-assessment and expectation management. Rosser et al. (2011) described adjusting therapeutic encouragement based on the user’s mood and other variables but do not explain this adjustment. The present study explored how the technology’s support should change according to the user’s level of pain and mood. Results indicated that in the case that the technology could detect pain level and mood, users wished for the technology to show that it had recognised the pain level and mood both on good days and bad days. The desire to see this information may reflect some of the scepticism expressed by interviewees regarding the technology’s ability to accurately recognise these variables. Many interviewees suggested that, instead, users could input their level of pain and/or
mood. In contrast, most questionnaire respondents indicated that it would be helpful for the technology to recognise and adjust the exercise programme and type of instructions to the user’s level of pain (94%) and mood (86%). However, it is possible that questionnaire participants were responding positively to the idea of adjusting the system to pain and mood and not considering the issue of automatic recognition of these factors. This issue of detection versus self-report of these variables warrants further study with clearer delineation between the functions of recognising and adjusting to pain/mood.

Regardless of whether pain and mood are detected or self-reported, results indicated that for most participants, adjusting the technology’s behaviour to the user’s pain and mood would be helpful. On days with more pain, 84% of respondents would like to receive reassurance that the exercises are safe. In the case of negative mood, 70% of users wanted to be reassured that ‘bad days happen and it will get better’. Most respondents also wanted the technology or virtual coach to ‘guide me in adjusting my goals for that day’s session’ during increased pain (68%) or a negative mood (67%). Questionnaire results also suggested a possible increased need for encouragement, as ‘give a lot a encouragement’ was selected by 67% of respondents for functions desired during a poor mood versus 57% for functions desired during a good mood. These questionnaire data corroborated interview results, which emphasised the need for adjusting expectations, reassurance, and encouragement during flare-ups and setbacks.

6.2.2 Activity Support

For support during physical activity, participants expressed interest in seeing demonstrations of exercises, seeing their own movement, receiving corrective feedback, receiving encouragement, and obtaining feedback on measures such as time or a count of repetitions. Activity support functions are discussed as follows: exercise demonstration, monitoring and feedback; virtual coach appearance; and user avatar appearance.

Exercise demonstration, monitoring, and feedback

Participants indicated that viewing their movements onscreen would be helpful for monitoring their movements and self-correcting. These results agree with those of Schönauer et al. (2011), who tested a game developed for chronic pain rehabilitation and reported that participants found it valuable to see their movement reflected in the game’s avatar. The present study also suggested a need for corrective feedback, which was based on the desire to benefit from exercises and to prevent injury. The concern with injury reflects the pain-related fear described in the fear-avoidance model (Leeuw et al., 2006). These findings echo those of Cranen et al.’s (2011) study of chronic pain patients’ attitudes towards telerehabilitation, in which patients expressed fear of negative outcomes from exercising without in-person supervision by a physiotherapist. Cranen et al. (2011) reported that patients viewed telerehabilitation as a complement to, not replacement for, in-person treatment. The present study suggests that even as a complement to in-person treatment, concerns regarding injury during exercise will likely remain and therefore must be addressed by the technology.

In addition to showing user movements, results suggested that participants would benefit from exercise demonstration, exercise metrics (e.g. time, number of repetitions), corrective feedback, and encouragement. Many participants saw the
virtual coach as an effective means of meeting these needs: P1 described the virtual coach as “a motivational force, somebody that can demonstrate maybe how things should be done, and then somebody who gives you positive feedback”. Research shows that animated exercise demonstrations can improve accuracy of exercise performance in healthy participants (Buttussi et al., 2006), and healthy participants have responded favourably to ongoing guidance, feedback, and encouragement provided by a coach (Asselin et al., 2005).

Ongoing performance feedback can be delivered in many ways: the mode of delivery can vary, e.g. visual or auditory, and the form of delivery can vary, e.g. information alone (“Reps: 5”), information with encouragement (“You have done 5 reps. You are doing well”), or imperatives (“You have done 5 reps. Now do 5 more!”). Research regarding the most effective methods of delivering feedback is limited but suggests that this likely depends on individual preferences (Asselin et al., 2005). This variation in personal preferences also emerged in the present study, as illustrated by P4’s example encouraging phrase “you can do this, just a little bit, and perhaps try a little bit further” and P5’s remark that “there’s nothing more irritating than somebody saying ‘now go a bit further’”. Overall, results suggested that people with chronic pain require encouragement and feedback adjusted to pain and mood, especially pain-related fear. For example, the function ‘push me a little’ was selected by fewer questionnaire respondents for the contexts of more pain (11%) versus less pain (39%) and negative mood (25%) versus positive mood (31%). This, again, highlights the importance of a reactive system that tailors its feedback to the user’s needs at that time, as well as one that delivers feedback according to individual preferences.

Virtual Coach Appearance

Results indicated that many people with chronic pain have poor body image, which is defined as body-related self-perceptions and self-attitudes, including thoughts, beliefs, feelings, and behaviours (Cash, 2004). Interview results reflected an overall strong negative reaction to exercise coaches with ‘ideal’ body types, whether these were real people in exercise videos or virtual coaches. This negative response to ideal virtual coaches seemed to result from both the desire to have a virtual coach that is relatable, i.e. similar to the user, and the wish to avoid feeling bad about one’s own body. P1 summarised the issue well:

You might want to get somebody sort of maybe a bit older, maybe a little fatter […] somebody that you can relate to as somebody that might be experiencing the same sort of problems that you might experience. [A virtual coach] gives some quite nice interpersonal reaction […] if it’s not too confrontational, it isn’t the body perfect, which frankly can make anybody feel rubbish about themselves.

Previous research has also reported that a virtual embodied agent’s similarity to the user and body form affect users’ reactions. Studies indicate that users respond more positively to embodied agents that look more similar to the user (Guadagno, Blascovich, Bailenson, & McCall, 2007; Nass & Moon, 2000). A study on weight and diet advisors reported that non-ideal (larger body shape) advisors evoked lower emotional distance and higher intentions to use the advisor than did ideal (slender) advisors (van Vugt, Konijn, Hoorn, & Veldhuis, 2009). In addition, heavier advisors were perceived as more trustworthy, which the researchers suggested may have resulted from the expectation that heavier advisors had more experiential knowledge,
i.e. they “know what it is to be big” (van Vugt et al., 2009, p. 581). This explanation is reflected in P1’s comments above and in P3’s suggestion that the virtual coach be “a little bit overweight, even someone who’s had pain himself”. Van Vugt et al. (2009) suggested that heavier users may have rejected the ideal e-health advisor in order to protect their self-esteem. This, again, agrees with the findings in the current study, in which participants described ideal-bodied virtual coaches as “scarily fit” (P4), “off-putting” (P2, P4) and “threatening” (P1). These results suggest that the appearance of a virtual coach, especially for people with chronic pain, can negatively affect the user’s emotions, potentially jeopardising their acceptance of the technology. Users should therefore have a choice of virtual coaches with various body types.

**User Avatar Appearance**

As with the virtual coach, body image was a concern with regards to the user avatar. Most participants with chronic pain did not wish to see a realistic representation of themselves. The most popular avatar representations selected in the questionnaire were ‘standard representation that does not look like me’ (46%) and ‘cartoon representation that can look any way I choose’ (42%). Indeed, 10% of participants selected ‘I do not want to see a representation of myself’. Only 10% of participants selected ‘representation that looks just like me’. Interviews suggested that the aversion to seeing a realistic avatar likely results from poor body image. This contrasts with Cui et al.’s (2009) study, in which healthy users with poor body image rated a depersonalised mannequin avatar lower and a mirror-image avatar higher than participants with good body image. The authors suggest that the participants with poor body image may have preferred the mirror-image avatars due to the greater preoccupation with body appearance that often accompanies poor body image. This preoccupation with body image may not apply to our sample, as it is possible that in people with chronic pain, low body image stems from different causes than in healthy people. The results of the present study strongly suggested that people with chronic pain would prefer the option to have an avatar that is not a realistic mirror-image.

Despite participants’ overall preference for a less personalised avatar, this type of representation may not be the most effective method of encouraging exercise adherence. In a study examining the effect of an avatar’s appearance on exercise levels in healthy people, participants watched an avatar running on a treadmill. Participants who viewed avatars created from photos of themselves exercised more the next day than participants who viewed avatars of others (Fox & J. Bailenson, 2009). Interestingly, PT3 reported a similar effect in her clinical practice: when she provided patients with photos of themselves performing exercises she obtained higher exercise compliance than when she provided stick-figure depictions of the exercises. Of course, there is also the possibility the any positive effects of viewing a realistic, personalised avatar would be overridden by a strong negative emotional reaction to viewing one’s own body. The effect of different levels of avatar personalisation on the users’ exercise adherence, engagement, and affective state requires further investigation.

**6.2.3 Post-Activity Support**

The primary form of post-activity support identified in the present study was information tracking. Seventy-eight percent of questionnaire respondents indicated that after an exercise session, they would like to see their exercise performance over a period of time. Interviews indicated that, for many, tracking activity and progress is a
key component of chronic pain self-management, both for building awareness of activity levels to inform pacing and for maintaining motivation. These results agree with the positive feedback participants provided regarding the automatic record keeping of Asselin et al.’s (2005) personal wellness coach. Similarly, Consolvo, Klansja et al. (2008) reported that their progress tracking display helped participants maintain awareness of their activity level and provided motivation to meet goals. In social cognitive theory, Bandura (2001) emphasises the importance of progress tracking for self-evaluation against personal goals. It is the attainment of personal goals that fosters satisfaction and feelings of self-worth (Bandura, 2001) and builds self-efficacy (Bandura, 1977). Supporting this theory of the power of tracking progress towards goals to foster self-motivation are studies showing that goal setting and progress tracking increase exercise adherence. In a meta-analysis of the use of pedometers to encourage increased physical activity, only studies requiring participants to set step goals and maintain diaries of their progress showed significant increases in physical activity (Bravata et al., 2007).

Despite the support for information tracking in the present study and previous research, there are potential complications that arise with chronic pain: (1) the occurrence of flare-ups/setbacks, and (2) the possibility that no progress will occur. In these cases, tracked metrics would reflect no improvement or apparent regression, which could threaten self-efficacy and motivation if perceived as failure (Bandura, 1977, 2001). Several solutions may address these concerns. One possibility is for the technology to adjust the time-scale on a progress display to show achievement: for example, while a graph of daily repetitions may show a decrease during a flare-up, a graph of average repetitions per month may still show an overall increase. Alternatively, the technology could display only attainment of that day’s goal, which should have been adjusted to be achievable according to the user’s present state. Another possible solution is allowing a range of metrics to be tracked such that users can focus on an area they can expect to improve or where preventing deterioration is the goal. For example, P4 noted that despite doing 40 minutes of exercise every day, she has “never managed to increase them or do more. […] But you know, I move very freely and that’s basically what I do it for, just to keep everything moving”. Despite her inability to increase the level of her exercise, P4 is able to motivate herself to continue regular exercise by focusing on a different metric of success: maintaining mobility. Finally, as discussed in 6.2.1 Pre-Activity Support, the technology can facilitate cognitive reframing to focus the user’s attention on positive outcomes and provide reassurance that a lack of apparent progress in exercise metrics does not indicate failure or a lack of benefit from the exercise. Further research should investigate how best to utilise information tracking to benefit people with chronic pain.

6.2.4 Engagement

Activities that are enjoyable and satisfying are intrinsically rewarding and hence are associated with strong motivation for continued performance of the activities (Ijsselsteijn et al., 2006). The present study suggested that an enjoyable interaction with the technology may increase motivation. As P7 commented, “I know there are people whose eyes would light up at the idea of a piece of technology and that would motivate them in itself”. Other comments suggested the desire for an element of fun. P3 emphasised that the pain management content “has to be made interesting, has to be fun”. Under the questionnaire item regarding preferences for the user’s avatar, one participant responded that he would like “famous people so I can make them do silly
Introducing enjoyment to the management of chronic illness has been explored in the paediatric population with games such as Click Health, Inc.’s “Bronkie the Bronchiasaurus” for asthma self-management and “Packy & Marlon” for diabetes self-management (Lieberman, 2001). For adults and children, enjoyment as a motivator for exercise has been explored for healthy users in “exergames” such as Wii Sports (Nintendo, 2006) and Kinect Sports (Microsoft Game Studios, 2010) and for patients with rehabilitation games (O’Huiginn, Smyth, Coughlan, Fitzgerald, & Caulfield, 2009; Schonauer, Pintaric, Kaufmann, Jansen-Kosterink, & Vollenbroek-Hutten, 2011). One such rehabilitation game targets people with chronic low back or neck pain, providing an adventure game through which users progress by treadmill walking, reaching, relaxing the trapezius muscle, and moving/rotating the cervical spine (Schonauer et al., 2011). A physiotherapist sets the goals and baselines for the game and patients play the game at the clinic. A preliminary 4-week evaluation showed that patients enjoyed the game, and there was a trend of improvement on pain, disability, and walking distance. This ‘serious game’ provides an example of how enjoyment can be incorporated into exercise for people with chronic pain.

In addition to making exercise itself more enjoyable, an interactive technology could also encourage physical activity by making associated activities enjoyable or satisfying such as by providing rewards for goal attainment. This was the motivation behind exploring different representations of progress in the current study. The garden metaphor presented to participants, which was inspired by Consolvo, McDonald et al. (2008), evoked mixed responses: some participants imagined enjoying an abstract representation related to their interests (e.g. P2: “I think that something quite playful would be quite nice. […] I think a garden would be nice.”) while others expressed a preference for more concrete representations (e.g. P1: “I would always rather look at the sort of stats and the slightly scientific version”). In the questionnaire, 17% of respondents said they would prefer an abstract representation, 38% selected the concrete graph representation, and 48% said they would like the option for both. It is unsurprising that personal preferences varied with regards to the progress visualisation, but it is difficult to predict actual responses without giving participants the experience of using the different visualisations. It is possible that more people would find the abstract type of representation engaging and rewarding than suggested. Consolvo, McDonald et al. (2008) reported that most participants found the garden motivating and that many participants were surprised by this. Lin et al.’s (2006) representation of goal attainment through the growth and happiness of a fish also evoked positive responses, with most participants reporting that the fish was motivating. P5 expressed this need to actually try the abstract progress visualisation: “I don’t know if it would make a difference because just ‘cause I think no, I might be totally wrong. […] As somebody who’s played Angry Birds, I know that you’ll do all sorts of things for minor satisfactions”.

Enjoyment and satisfaction are powerful motivational forces (Ijsselsteijn et al., 2006). Previous research and the current study suggest technologies supporting behaviour change, including chronic pain self-management, should explore incorporating elements of fun to increase user engagement with the technology.
6.3 Identified User Needs and Current Technologies

The present study identified a number of user needs for a technology supporting long-term exercise adherence for chronic pain self-management. Table 11 summarises these requirements.

<table>
<thead>
<tr>
<th>Required Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Activity</strong></td>
<td></td>
</tr>
<tr>
<td>Provides flexible goal setting*</td>
<td>Allows users to set different types of goals, including progress and maintenance goals for performance and functional abilities</td>
</tr>
<tr>
<td>Facilitate self-assessment</td>
<td>Guide the user in assessing his/her current state, including pain, energy, and mood</td>
</tr>
<tr>
<td>Facilitate adjusting session</td>
<td>Guide the user in adjusting sessions goals to the appropriate level for their current state</td>
</tr>
<tr>
<td>goals / setting expectations</td>
<td></td>
</tr>
<tr>
<td>Provide encouragement / reassurance</td>
<td>Provide encouragement to exercise and reassurance regarding the safety of the exercises (users should be able to adjust this form of support to match their preferences)</td>
</tr>
<tr>
<td><strong>During Activity</strong></td>
<td></td>
</tr>
<tr>
<td>Provide exercises tailored to user</td>
<td>Tailor the exercises to the user's physical abilities, functional goals, and current state of pain/energy/mood</td>
</tr>
<tr>
<td>needs</td>
<td></td>
</tr>
<tr>
<td>Demonstrate exercises</td>
<td>Demonstrate the exercises through a virtual coach</td>
</tr>
<tr>
<td>Provide option for non-ideal</td>
<td>Provide a selection of virtual coaches with different appearances, including non-ideal, and/or provide the option to design the virtual coach</td>
</tr>
<tr>
<td>virtual coach</td>
<td></td>
</tr>
<tr>
<td>Show user's movements</td>
<td>Show the user's movements through an avatar</td>
</tr>
<tr>
<td>Provide avatar choices with</td>
<td>Provide avatar choices across a range of personalisation, from a standardised form to realistic</td>
</tr>
<tr>
<td>various levels of personalisation</td>
<td></td>
</tr>
<tr>
<td>Correct movements</td>
<td>Provide the option for corrective feedback on movements and possibly address the user's pain-related fear of injury</td>
</tr>
<tr>
<td>Provide feedback on exercise</td>
<td>Provide measures of progression/performance, e.g. count of repetitions, time elapsed/remaining</td>
</tr>
<tr>
<td>progression/performance</td>
<td></td>
</tr>
<tr>
<td>Provide encouragement /</td>
<td>Provide encouragement and positive feedback (users should be able to adjust this form of support to match their preferences)</td>
</tr>
<tr>
<td>positive feedback</td>
<td></td>
</tr>
<tr>
<td><strong>Post-Activity</strong></td>
<td></td>
</tr>
<tr>
<td>Display tracked information</td>
<td>Display tracked measures of progress/goal attainment</td>
</tr>
<tr>
<td>Allow user to select what information</td>
<td>Allow the user to select what information to track. Enable user to input physical activities performed throughout the day (e.g. pedometer step count)</td>
</tr>
<tr>
<td>to track</td>
<td></td>
</tr>
<tr>
<td>Provide options for different goal/</td>
<td>Provide options for different goal/progress visualisations such as graphs or abstract representations related to interests</td>
</tr>
<tr>
<td>progress visualisations</td>
<td></td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Adjust guidance/feedback to user's</td>
<td>Adjust guidance and feedback to the user's current state, including pain and affect</td>
</tr>
<tr>
<td>current state</td>
<td></td>
</tr>
<tr>
<td>Facilitate use of CBT</td>
<td>Facilitate the use of CBT skills, e.g. cognitive reframing</td>
</tr>
<tr>
<td>Promotes engagement</td>
<td>Promote engagement with the technology and/or activity with enjoyable/satisfying interactions</td>
</tr>
</tbody>
</table>

Table 11. User requirements identified in the present study for a technology supporting long-term exercise adherence for chronic pain self-management. *Although specifics of goal setting were not explored in the present study, allowing flexible goals emerged as a key requirement.
Promising systems for encouraging regular exercise exist as commercial and research fitness technologies. Although commercial systems, such as Nintendo Wii Fitness, have been used in some rehabilitation clinics, they are not always suitable for a clinical setting (Anderson, 2010). For example, commercial exergames may give negative feedback, which can be inappropriate for patients (Lange, Flynn, & Rizzo, 2009). Table 12 presents an analysis of a representative selection of relevant commercial and research technologies against the user requirements identified in this study. The analysis indicates that current technologies do not meet all the needs of the chronic pain population. The primary components lacking from current fitness technologies are: facilitation of self-assessment and management of expectations/goals; appropriate visual representations of the user and any virtual coach to address body image sensitivities; and encouragement that incorporates key messages for chronic pain management, facilitates using cognitive behavioural therapeutic skills, and adjusts responses in a personalised way according to the user’s pain level and affective state, including pain-related fear of movement. Current e-health technologies fill some of these gaps, but still do not meet all user requirements. Rosser et al.’s (2011) device was designed to address activity pacing and therefore does not provide support for exercise. In contrast, Schönauer et al.’s (2011) game was designed to encourage engagement but does not address the cognitive and emotional aspects of pain management. In addition, many requirements are only partially met; this is especially true of the requirements for flexible goal setting and information tracking. Of all the technologies that allow goal setting, only Rosser et al.’s (2011) system addresses functional goals, and no system gives the user complete control over information tracking. Thus, while some behaviour change approaches in persuasive technologies and patient support approaches in e-health technologies may support chronic pain self-management, the chronic pain population has many needs that are not addressed by current technologies.
<table>
<thead>
<tr>
<th>Technology/Study</th>
<th>Healthy Users</th>
<th>PT Patients - Acute Injury</th>
<th>Chronic Pain Users</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Activity Functions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provides flexible goal setting</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Facilitates self-assessment</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilitates adjusting session goals/setting expectations</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provides encouragement/reassurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity Functions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provides exercises tailored to user needs</td>
<td></td>
<td>✓*</td>
<td>✓*</td>
</tr>
<tr>
<td>Demonstrates exercises</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Provides option for non-ideal virtual coach</td>
<td></td>
<td>future</td>
<td></td>
</tr>
<tr>
<td>Shows user’s movements</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provides avatar choices with various levels of personalisation</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrects movements</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Provides feedback on exercise progression/performance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Provides encouragement/positive feedback</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Post-Activity Functions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displays tracked information</td>
<td></td>
<td></td>
<td>future</td>
</tr>
<tr>
<td>Allows user to select what information to track</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Provides options for different goal/progress visualisations</td>
<td></td>
<td></td>
<td>future</td>
</tr>
<tr>
<td><strong>General Functions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusts guidance and feedback to user’s current state</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Facilitates use of CBT</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Promotes engagement</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 12. Analysis of current fitness and clinical technologies against user needs identified in the present study. Symbols & terms: ✓ indicates fully met requirements; ○ indicates partially met requirements; * indicates a function performed/accessed by the patient’s physiotherapist; ‘future’ denotes a proposed function for future development; PT means physiotherapy.
6.4 Limitations and Future Research

The generalisability of the present study is limited by the degree to which our participants represent the chronic musculoskeletal pain population. Although interviews are a valuable source of rich data, they require time investment from the participant and the researcher and therefore are limited in number. Within this limited number, deliberate recruitment of a representative sample of participants was not possible due to restrictions of time and permitted recruitment methods. Consequently, the sample of interviewed participants was determined by convenience. Similarly, a main limitation of online questionnaires is the difficulty in obtaining a random sample that is generalisable to the larger population (Kraut et al., 2004). We sought to increase the variation within the sample by using several sites of distribution, but the sample inevitably reflects a self-selected group of Internet users. Future research should seek a sample representative of the larger population of people with chronic musculoskeletal pain to validate the generalisability of our findings.

Another limitation was the inability to allow participants to use motion-sensing fitness technologies, such as the Xbox Kinect, due to ethical concerns with asking people with chronic pain to perform exercises intended for healthy users. Participants less familiar with relevant technologies may have had difficulty appraising their needs with respect to possible technological solutions (De Rouck et al., 2008). We minimised this limitation by asking participants about their needs outside of the context of technology, as well as by presenting participants with movie clips and explanations of relevant technologies. Nevertheless, future research is needed to address this limitation and confirm our findings.

Some concepts arose in later interviews that could not be fully explored due to limited time and available participants. One such concept was that of trusting the technology to give appropriate advice. With regards to the concern with the safety of exercises, most participants expressed only a need for the technology to reassure the user that the exercises are safe. However, two participants were concerned with the ability of the technology to adequately adjust its advice to each user.

P5: This is where I’d actually want a physio […] because how does the programme actually know what’s going on [when my pain level changes].

PT4: It would need to understand my history and what has happened that I could be confident that it understands what’s happened to me […] so that then when it’s telling me to do things or that, then I know that yes, it understands my condition completely.

This concept of trust warrants further research, especially as trust is an important factor in people’s use of Internet health portals (Luo & Najdawi, 2004), which is analogous to the use of other health technologies. Trust is also an important factor in the development of a relational agent, such as a virtual coach, that builds a long-term social-emotional relationship with users (Bickmore & Picard, 2005).

Two interview participants also indicated a desire for triggers/alarms reminding users to perform exercises or take breaks from activities for pacing. This agrees with
O’Conner’s (2008) requirement for reminders to exercise. Furthermore, ‘just-in-time’
triggers have been found to be a promising method of encouraging a target behaviour,
and advances in context-aware computing, such as accelerometers that detect physical
activity, are creating new opportunities in this area (Intille, 2004). The use of triggers
to encourage exercise adherence in chronic pain management should be further
explored.

Another concept requiring further study is that of goal setting. Although the
importance of goal setting emerged in this study, the specific activities involved in
successful goal setting were not addressed. The role goal setting plays in behaviour
change has been studied in previous research (e.g. Consolvo, Klasnja, McDonald, &
Landay, 2009; Locke & Latham, 2002; Shilts, Horowitz, & Townsend, 2004). As a
critical component of self-motivation (Bandura, 2001) and pain self-management
(British Pain Society, 2007), goal setting techniques should be investigated in future
research on a supportive technology for chronic pain self-management.

Also requiring additional research are the issues of pain management approach
and body representations. Pain management approach, particularly with regards to
instructing patients in biomechanically ‘correct’ movements, would necessarily
influence the content of a supportive technology for chronic pain self-management.
Further research of possible pain management approaches and their applications to a
technology is required. The present study also identified body image as a prevalent
concern among people with chronic pain. While most participants clearly stated their
preference for a less personalised avatar, research suggests that realistic avatars may
be more effective motivators for physical activity (Fox & Bailenson, 2009). Future
research should investigate the effect of varying degrees of personalisation of user
avatars on performance and affect to determine the most effective and appropriate
options.
CHAPTER 7.  CONCLUSION

Chronic pain is a widespread health concern that negatively impacts individuals through physical, psychological, and social effects and negatively impacts society through treatment costs and lost work (“The British Pain Society - FAQs,” 2008). Multidisciplinary PMPs, which teach patients the skills to manage their pain and improve their functioning, show efficacy for addressing this health problem (Scascighini et al., 2008). However, ongoing patient adherence to management behaviours is a challenge, jeopardising long-term success (Turk & Okifuji, 2002). Among the pain management behaviours that pose difficulty is regular exercise (Medina-Mirapeix et al., 2009), yet regular exercise is an important behaviour associated with improved long-term outcomes (Petersen et al., 2007; Taimela et al., 2000).

The present study applied user-centred methods to investigate users’ needs and expectations for an interactive technology supporting exercise in people with chronic musculoskeletal pain after completion of a structured treatment programme. Needs were elicited through interviews with two types of stakeholders: people with chronic musculoskeletal pain and physiotherapists. Interview results were validated with a wider sample of people with chronic musculoskeletal pain through an online questionnaire. Results indicate a need to address the physical, cognitive, and emotional experiences of chronic pain. The primary user requirements identified were: support for self-assessment and setting appropriate expectations; personalisation including exercises tailored for the user’s physical needs and goals; exercise monitoring and corrective feedback; encouragement; tracking of selected behaviours; sensitivity to body-image concerns; and adjustment of guidance and feedback to the user’s present state, including pain and affect. The present study also provided insight into how the user’s behavioural and affective state should modulate guidance/feedback; results suggested that during increased pain or negative mood, users would require reassurance of the safety of exercises and possibly increased encouragement.

Encouraging exercise is an active area of research in the fields of persuasive design, e-health, and rehabilitation games. However, the chronic pain population has largely been excluded from this research. Technologies designed for healthy users do not provide the cognitive and emotional support required by people with chronic pain. Those projects that do target chronic pain support do not address user needs from pre-activity through to post-activity. Our results provide evidence for unique needs for physical activity support for individuals with chronic pain, as well as some commonalities with the needs identified in persuasive design research. We also identified several important areas for future research, including goal setting and the effect of personalised/depersonalised user avatars on the affect and motivation of people with chronic pain. Our results therefore contribute to both academic research on technology-based support for a unique population of users and the design process of a technology to support physical activity in people with chronic pain.
REFERENCES


APPENDICES

Appendix 1. Semi-structured interview questions

The following questions were used to guide interviews with participants with chronic pain. Questions were adjusted as needed for physiotherapists.

*Interview guideline:*
Thank you for agreeing to be interviewed. Before I begin, I’d like to ask if it’s okay to record our conversation. This is just so that I can go back to it later for my research. With your consent, an anonymised transcript of our interview may be included in the appendix of my thesis.

I would like to ask you some questions about yourself before we start. If you feel uncomfortable answering any of the questions please let me know and we can go on to the next question.

- How old are you?
- How long have you been affected by chronic pain?
- Have you ever done a Pain Management Programme or seen a physiotherapist for your pain? How long ago?

This project is about developing healthcare technology to support people with chronic musculoskeletal pain to carry out physical activity. The technology will be able to detect people’s movement and show it on the screen. This is similar to the Xbox Kinect games.

Did you watch the video I sent you? This video shows one example of how a technology can detect and depict a player’s movement. How familiar are you with technology like video games?

In addition to detecting people’s movement, the technology we are developing will be able to recognise and adapt the exercise programme or type of instruction to your mood and your level of pain. The technology could also store information that you would like to see later, such as what you did during an exercise session.

Take a moment to imagine a dream technology for supporting the physical exercises of people with chronic pain. Could you please describe what it would do to support you?

Do you think it would be helpful for the technology to recognise and change the exercise programme or instruction according to the user’s mood?
   If yes: what should change in response to mood?

Do you think it would be helpful for the technology to recognise and change the exercise programme or instruction according to the user’s level of pain?
   If yes: what should change in response to level of pain?

Like you saw in the Kinect video, many new technologies for supporting physical activity include a computer character to demonstrate the movement for the user and to
provide feedback. The computer character often takes on the role of a virtual coach like in a fitness class. In your dream technology, would there be a virtual coach?

Describe how your ideal virtual coach would support people with chronic pain?

What role should this virtual coach take on? For example, would he/she be like a physiotherapist? Can you describe how the virtual coach should behave?

Should the virtual coach’s behaviour change according to the user’s level of pain? If yes: how?

Should the virtual coach’s behaviour change according to the user’s mood? If yes: how?

A patient can be represented by the technology in many different ways, from very abstract to more realistic. Please look at the first link I sent you. [Movie clips of avatars were shown or emailed to participants. Feedback on several different examples shown during early interviews were used to select four movie clips for the remaining interviews and the questionnaire. Images from those movie clips are displayed below]

After each movie clip:
Is there anything that would be useful for the user to see in this representation?

What kind of representation do you think would be useful for patients to see when watching themselves doing exercises?

What other types of information would be helpful to see while you are doing exercises? (For example, seeing how long you hold a stretch or how many repetitions of a movement you do)

Is there any information you think the technology should store for you to see later? (For example, information about how you performed a movement or how many repetitions of a movement you did). How would this information be helpful to you?

(If there is time, discuss presentation of information - charts, abstract representation of goal attainment, etc.)
### Appendix 2. Interview information sheet and consent form

<table>
<thead>
<tr>
<th>Information Sheet for Participants in Research Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>You will be given a copy of this information sheet.</td>
</tr>
</tbody>
</table>

**Title of Project:** Emotion & Pain Project

This study has been approved by the UCL Research Ethics Committee [Ethics number]: Staff/1011/005

**Name, Address and Contact Details of Investigators:**

- Dr Nadia Bianchi-Berthouze
- UCL Interaction Centre
- MPEB 8th floor
- University College London
- Gower Street
- London WC1E 6BT
- United Kingdom
- +44 (0)20 7679 0690

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

This project aims to develop healthcare technology to help patients with chronic pain by providing feedback on their movement performance and psychological support during self-directed rehabilitation.

We will be interviewing you to gather the needs for such technology. The interview will last approximately half an hour.

All data will be handled according to the Data Protection Act 1998 and will be kept anonymous. Researchers working with Dr Nadia Berthouze will analyze the data collected. The information gathered will be used to understand chronic pain patients’ requirements for physiotherapy technology.

With your permission, we would like to audio record the interview and use an anonymised transcription in thesis work.

It is up to you to decide whether or not to take part. If you choose not to participate it will involve no penalty or loss of benefits to which you are otherwise entitled. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.
Informed Consent Form for Participants in Research Studies

Title of Project: Emotion & Pain Project

This study has been approved by the UCL Research Ethics Committee [Ethics Number]: Staff/1011/005

Participant’s Statement

I ………………………………………………………………………………………………………………………

agree that I have

- read the information sheet and/or the project has been explained to me orally;
- had the opportunity to ask questions and discuss the study;
- read the guidelines on the use of computer game used for the study;
- I understand that my participation will be audio recorded and I am aware of and consent to the analysis of the recordings.

For the following, please circle “Yes” or “No” and initial each point.

- I agree for the interview transcript to be used by the researchers in further research studies
  YES / NO initials:_____________

- I agree for the anonymised interview transcript to be used by the researchers for teaching, conferences, presentations, publications, and/or thesis work
  YES / NO initials:_____________

I understand that I am free to withdraw from the study without penalty if I so wish and I consent to the processing of my personal information for the purposes of this study only and that it will not be used for any other purpose. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: Date:

Investigator’s Statement

I ………………………………………………………………………………………………………………………

confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: Date:
Appendix 3. Coded interview transcripts

The following are samples of coded interview transcripts.

P1:

somewhere. 'Well actually that’s really good, that’s all going the right way you
know and you know, slow and steady it’ll be fine.' So I don’t know whether there’s any
audio feedback can be built in but I think encouragement. And I mean this really is
dream, technology and of course there are days when you have a setback and you
can’t do as you did the day before. And I think dealing with setbacks is one of
the most complex issues around dealing with chronic pain, and rehab and chronic
pain. Because what happens if you have a setback for whatever reason, it’s very
easy to assume that you’re going to go all the way back to where you started. It’s very
unlikely – you might just fall back a little way. Let’s say you had the flu or a cold
or something and you are not able to exercise for a couple days – when you come back
to it won’t be at the level you were before you stopped. So again this
encouragement and motivational you know, ‘that’s okay, well that’s only 5 today but
tomorrow it will be 6 1/2 type thing. That is the sort of feedback you’d get if you were
standing with a physiotherapist. They’d be focusing on the positives not worrying
about any of the negatives.

T: So how do you imagine the technology delivering that encouragement? One thing
you mentioned was verbally. So those sorts of statements like ‘Don’t worry about it’…

P1: Yea. ‘You’re doing fine’. You know, ‘Remember taking it steady is really
important’. Because everybody wants, well in my experience, everybody wants to get
better quicker and of course the worst thing you can do to get better quicker is to do
too much. And most chronic pain patients do this. They have a great day and they
sort of go for broke on a good day and then of course and they then get followed by 2
bad days because they’d done too much the day before. So it’s learning, it’s pacing
and taking steady. Do enough but not doing too much. It’s difficult because mainly
you’re just frustrated that you can’t run around like everybody else does. So all those
messages about being kind to yourself and reaching your goals and being positive
about the goal you’ve reached but not getting down if today is a day when you can’t
do it for whatever reason. So I mean it – the technology, I would think it quite complex
because you don’t want some sort of patronizing bland coming from the machine
cause I think that might be a bit irritating.

T: So I guess that goes hand in hand with how the technology should respond to the
user’s mood and level of pain, that sort of goes together with this idea of setbacks.

P1: Yea

T: Can you think of anything perhaps more specifically about how it should change
the exercise programme or the type of feedback if the person is having a good
day or a bad day.

P1: Well I would imagine that it would be useful you know - so let’s say the patient
gets into wherever it turns on the Xbox. If the first sort of 5 minutes or 3 minutes were
sort of saying ‘well before we start your programme why don’t you have a think about
how you’re feeling today. What is your general level of tiredness? What is your
general level of pain? Have you thought about what you’re going to try to achieve
from today’s session? Rather than them getting into the session and then finding that
they can’t do it because they’re too tired or it’s too difficult because that’s very
demotivating. If you sort of focussed on it before you start, know what you’re
expectations are going to be, you’re much more likely to have a positive outcome as a
result. So I would’ve thought just a short assessment before anybody starts
anything. ‘Let’s just stand there and think a minute how you’re feeling’. And then, so
maybe, let’s say for each programme there’s level 1 to 5 and you normally operate at
4. You could say well you know today I’m going to do a level 3 programme and the
fact that doing a level 3 programme is better than doing no programme at all is a
positive and not to be negative about the fact that you can’t do a level 4 programme
today. There’s another day for level 4. So the patient probably then has to choose,
has to make an objective decision about how they are feeling and what would be a
good thing for them to do on that day.
P2: Yes, I do. I could see that that could be very useful.

T: Can you think about how it should change if the person is in a more positive or a more negative mood?

P2: There will be times when it’s much harder to be motivated and sometimes the prospect of doing a full set of exercises or so might just be more than you can face. But if it was something that you could say I really don’t feel in the mood for doing whatever it might be, half an hour or an hour today, but maybe I can do 5 minutes now and 5 minutes later. So that kind of thing maybe.

T: So perhaps tailoring the length or the expectation of the level of exercise to the person’s mood.

P2: Yea. And I suppose another thing might be to something that reminds you of the rewards to be gained or the reasons why you’re doing it and you know the sort of encouragement and perhaps encouragement – maybe perhaps reflecting back on what you’ve achieved so far as a way of encouraging as well.

T: So encouraging both by reminding about why you’re doing it and also by looking at your progress so far.

P2: Yes

T: Okay. And do you think if it were also adjusting to your level of pain, are those sort of the same changes it should make or can you think of anything else?

P2: Well it would, I think um there would be concerns about safety and the possibility of harm and making things worse so reassurance and making it clear that whatever level of pain is recognized in the, in what you’re supposed to do. So yea, reassurance that that’s taken into account, I guess.

T: Ah, that’s very helpful. So basically it would say to the person it seems like you’re in a lot of pain and these exercises that we’re recommending are still safe for you to do.

P2: Yea

T: Okay. So like you saw in the video of the Kinect, many of these sorts of technologies include a type of character that demonstrates the movements and may even provide feedback.

P2: Yes

T: So they sort of take on the role or a virtual coach.

P2: Yes

T: Do you think that this would be something useful in your dream technology?

P2: Yes, I think so. It seems to, I mean from the little that I’ve done from these sorts of games, it seems to be helpful to have a human sort of figure. I guess the question is whether you think it’s um, you know something they look so impossibly fit, beautiful, unlike you, it could be off-putting I suppose.

T: Yea, sure. So you think the coach should have a more quote average, normal type of look.

P2: Yea
symptoms, the way in which they are interpreting their own ability. And to get people to re-evaluate – cause often what happens when people have a flare-up, they can go on to a whole track of negative thinking and if we can get to a point where we can do some cognitive reframing, restructuring, call it what you will, to get people to view their this as just something that was expected because we know they’re going to flare-up again, and help them through it. I think that that can be helpful and also to start getting them to plan alternative scenarios which are a little bit more positive. And I think that that, hopefully, that is what some technology could do. As I say, you know, to a certain extent it’s being used in other conditions – phbias and depression, so I think if we’re really clever, in the future – you asked me what is the dream technology – well this is the dream technology.

21 Yea

22 Because it’ll probably help do some of that.

23 Okay, great. That’s very helpful. So in addition to that sort of helping them to cognitively reframe their thoughts, what about the exercises for that day themselves – would those change if they’re having a bad day or having a flare-up?

24 I think so. I think that what we would do with something like that is help people – when people are like that they tend to guard much more. This is my belief, not necessarily – but certainly some of the evidence demonstrates that people who catastrophize tend to do more guarding, muscular guarding. And by doing some simple relaxation and getting people to continue with some simple activities, because what we wouldn’t really want is people just to opt out completely. I think the main thing that people do is that when they go a flare-up they get out of the pattern and then they don’t get back into it again. And often when you talk to people, they say ‘oh I had this real flare-up and it lasted for 2 weeks’ and then you talk to them and say ‘and that was 3 weeks ago – what have you been able to do since?’ ‘Well, I just got out of the habit and you know how it is – I just haven’t been able to get back to it.’ And I think that is because they don’t, they become very avoidant during those periods and it’s a good idea to do something rather than do nothing. And I think that obviously that could be a key point and we could actually reactivate people.

25 Mmhhmm. Okay. So in terms of adjusting their exercises for the day, when you are giving them those sort of more simple exercises – cause I’ve read some literature about trying to keep the routine fairly constant but gradually pacing and increasing. so when you have that type of flare-up, do you move back in the pacing or -

26 I think that you will now find anybody who – there’s this idea that no more on a good day and no less on a bad day – I don’t think you’ll find any patient who actually can say hand on heart that they stick to that.

27 Okay

28 Because they do become more avoidant and I think they do reduce their activities. And I think that actually for people who are having a severe flare-up, a day when they crop back their physical activities is not a bad thing, provided that you could actually see – what you often have to do, I think, with people - I mean this is talking clinically, if I were in the room with a patient - would first be to see whether things are quite as bad as they are perceiving them. And whether they can actually do something. I think that’s one thing. Or whether people, you know, have sustained an injury – well not sustained an injury, they’re unlikely to have done – but to try and, by doing that you might actually get people to start doing activity anyway but I don’t think that we would expect people to continue doing exactly the same on a severe flare-up day because I would think you might run the risk of alienating the person from the therapist or the technology if you try to insist upon it. But by trying to get people to actually do something even on those flare-up days and they can help reframe the way in which they’re viewing that, almost to learn that they can continue to do something, I think that
Appendix 4. Questionnaire

The following questionnaire was posted online.

We would like to invite you to complete a questionnaire that is part of a research study run at University College London. This project aims to develop healthcare technology to support people with chronic musculoskeletal pain when they do physical activities. This questionnaire will help us understand the type of support needed.

We can only provide helpful technologies by asking people with chronic pain what they think. We would be very grateful for your help with this. The questionnaire will take approximately 15 minutes to complete.

You should only participate if you want to; choosing not to take part will not disadvantage you in any way. If you have any questions, please contact us at talie.swann-sternberg.10@ucl.ac.uk.

If you would like to take part, please click the Start button below. By clicking Start, you are consenting to participate in this study. If you decide to take part you are still free to withdraw at any time and without giving a reason. All data will be collected and stored in accordance with the Data Protection Act 1998. The questionnaire does not ask for any identifying information; responses are completely anonymous.

Thank you!

Title of Project: Emotion & Pain

This study has been approved by the UCL Research Ethics Committee

Ethics number: [Staff/1011/005]

Project investigator: Dr Nadia Berthouze, University College London, Tel: 020 76790990

Researchers: Aneesha Singh, Tal Swann-Sternberg
Technology feedback

Please complete the following:

1. Age

2. Sex
   - Male
   - Female

3. What type of chronic pain are you affected by?
   - Musculoskeletal
   - Other

4. How many years have you been affected by chronic pain?

5. Please rate your pain on average by indicating a number below.
   - No pain
   - 1 2 3 4 5 6 7 8 9 10
   - Extreme pain

6. Please indicate your peak pain in the last month on the scale below.
   - No pain
   - 1 2 3 4 5 6 7 8 9 10
   - Extreme pain

7. Have you ever been treated by a physiotherapist for your pain?
   - Yes
   - No
Please rate how important it is that your physiotherapist does the following:

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Not Important at all</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Demonstrates exercises</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Corrects your movements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Encourages you to exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Gives praise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Sets exercise goals with you</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Tracks your progress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. How familiar are you with video games such as those on the Xbox Kinect or Nintendo Wii?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- I have never seen or heard about these game systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- I have watched others play Kinect and/or Wii games</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- I have played Kinect and/or Wii games on occasion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- I have played Kinect and/or Wii games many times</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>42%</td>
<td></td>
</tr>
</tbody>
</table>
15. Please watch this short video of a fitness game on Xbox Kinect. (Note: the video becomes silent after the first few seconds)

When you are finished, click Next. (Do not click on the other video thumbnails that appear at the end of the first video)

We are developing technology to support physical activity. This technology will be able to detect a user's movement and display it with a computer character, like the Xbox Kinect. The technology will also be able to recognize and adapt the exercise programme to the user's mood and level of pain. The technology could also store information that you would like to see later, such as replaying the movement you performed during an earlier exercise session.

Take a moment to imagine your dream technology for supporting physical activity.

16. How helpful would it be to see exercises demonstrated by a computer character, such as the instructor computer character in the Kinect video?

1 2 3 4 5
Not helpful 0 0 0 0 Very helpful

17. What other support would you like the computer character to provide? (select all that apply)

☐ Corrects your movements
☐ Encourages you to exercise
☐ Gives praise
☐ Sets exercise goals with you
☐ Other

☐ Back ☐ Save ☐ Next
Technology feedback

18. Would it be helpful for the technology to be able to recognize and adapt the exercise programme and type of instruction to your level of pain?
   - Yes
   - No
   - Not sure

19. On a day with less pain, I would like the technology / computer character to (select all that apply)
   - Show that it has recognized my level of pain
   - Push me a little
   - Remind me not to exercise too much
   - Be more upbeat
   - Remind me of my progress so far
   - I am not sure
   - Other

20. On a day with more pain, I would like the technology / computer character to (select all that apply)
   - Show that it has recognized my level of pain
   - Empathize with me
   - Reassure me that the exercises for that session are safe
   - Guide me in adjusting my goals for that day's session
   - Suggest different goals for that day's session
   - Push me a little
   - Remind me not to exercise too much
   - Be more serious
   - Remind me of my progress so far
   - Remind me of why exercising will help me
   - I am not sure
   - Other

Technology feedback

21. Would it be helpful for the technology to be able to recognize and adapt the exercise programme and type of instruction to your mood?
   - Yes
   - No
   - Not sure

Technology feedback

58%

Technology feedback

82%

Technology feedback

85%
### Technology Feedback

22. When I am in a good mood, I would like the technology / computer character to (select all that apply)
- [ ] show that it has recognized my mood
- [ ] praise my good mood
- [ ] give a lot of encouragement
- [ ] push me a little
- [ ] remind me not to exercise too much
- [ ] be more upbeat
- [ ] I am not sure
- [ ] Other

23. When I am in a low or negative mood, I would like the technology / computer character to (select all that apply)
- [ ] show that it has recognized my mood
- [ ] empathize with how I am feeling
- [ ] reassure me that bad days happen and it will get better
- [ ] guide me in adjusting my goals for that day's session
- [ ] suggest different goals for that day's session
- [ ] give me a lot of encouragement
- [ ] push me a little
- [ ] remind me not to exercise too much
- [ ] be more serious
- [ ] remind me of my progress so far
- [ ] remind me of why exercising will help me
- [ ] remind me that my emotions can affect my pain and my movements
- [ ] I am not sure
- [ ] Other

---

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not helpful</td>
<td></td>
<td></td>
<td></td>
<td>Very helpful</td>
</tr>
</tbody>
</table>

---

24. How helpful would it be for the technology to show your movements as you do your exercises?

---

71%
Technology feedback

There are many ways that the user can be represented in this type of technology, from very abstract to more realistic. You will now see some examples.

Please watch this video and then answer the questions below. (Do not click on the other video thumbnails that appear at the end of the first video)

26. How much would seeing your movements this way make you want to move?

Does not make me want to move at all 1 2 3 4 5 Definitely makes me want to move

.................................................. 78%
Please watch the following video and then answer the two questions below (Do not click on the other video thumbnails that appear at the end of the first video).

26. How much would seeing your movements in this way make you want to move?

- Does not make me want to move at all
- 1
- 2
- 3
- 4
- 5
- Definitely makes me want to move

81%

27. How much would seeing your movements this way make you want to move?

- Does not make me want to move at all
- 1
- 2
- 3
- 4
- 5
- Definitely makes me want to move

84%
Technology feedback

Please watch the following video and then answer the two questions below (Do not click on the other video thumbnails that appear at the end of the first video)

![Video Thumbnail]

26. How much would seeing your movements this way make you want to move?

Does not make me want to move at all  □  □  □  □  □  Definitely makes me want to move  □

[87%]

29. Which of the following options would you like for your on-screen representation? (select all that apply)

☐ A standard representation that does not look like me
☐ A representation that shows only my outline
☐ A representation that looks just like me, as if someone timed me
☐ A cartoon representation that can look any way I choose
☐ A representation that shows my facial expressions
☐ A representation that shows what muscles I am using
☐ I do not want to see an on-screen representation of myself
☐ I am not sure
☐ Other ____________________

[90%]
### Technology feedback

**30. What information would be helpful for you to see *during* your exercises? (select all that apply)**

- [ ] Number of repetitions
- [ ] Holding time for a stretch
- [ ] Extent of movement (e.g. 20° forward bend)
- [ ] Goal for that exercise session
- [ ] Information from your last exercise session (e.g. number of repetitions)
- [ ] I am not sure
- [ ] Other

**31. What information would you like the technology to store for you to see *after* your exercises? (select all that apply)**

- [ ] Number of repetitions
- [ ] Holding time for a stretch
- [ ] Extent of movement (e.g. 20° forward bend)
- [ ] Goal for that exercise session
- [ ] Exercise performance over a certain period (e.g. over the last month)
- [ ] Replay of your exercises through your on-screen representation
- [ ] I am not sure
- [ ] Other

---

*[96%]*
Information on your exercise sessions can be represented in many different ways. Here are two examples of how your progress could be represented on the screen.

#1 One way to show your progress is with a representation based on your interests. For example, someone interested in gardening may want to receive items to put in a virtual garden when he/she achieves a goal.

![Garden representation](image)

You reached your goal!
Choose an item to add to your garden.

#2 Another way to show your progress is with charts, graphs, and tables.

![Bar chart](image)

Number of forward bends per session

<table>
<thead>
<tr>
<th>Number of forward bends</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

32. Please choose the statement that best describes your opinion:

- [ ] I would prefer to see a representation based on my interests like #1 (garden)
- [ ] I would prefer to see a representation like #2 (graph)
- [ ] I would like the option to see both types of representations
- [ ] I would not like to see any type of representation
- [ ] I am not sure
- [ ] I would like to see a different type of representation: [ ]
Appendix 5. Interview concepts: participant quotes

Additional participant quotes exemplifying identified concepts are presented below.

5.1 Pain Management Approach

Correct Posture/Movement

Most participants were concerned with correcting postures and doing exercises correctly.

P1: One of the most important things in doing that exercise is to make sure your posture is correct and that you’re not, say, arching you’re back as you go up or sticking your bottom out or waving your leg off to the left.

P4: Otherwise you wouldn’t know if you’re getting the best out of it.

P6: I think it’s critical when you are not fit, and you have problems like chronic pain, and you want to do yoga or anything like this, […] if you do anything wrong, it can jeopardise any improvement that you may have done to date.

PT4 was opposed to instructing patients in ‘correct’ postures.

PT4: I guess my concern about, for example, being really focused on posture is that […] might give them the idea that there’s such a thing as a bad posture.

PT4: […] although there are many questions about ‘how should I lift and what should my posture be’, we kind of address them in a ‘actually it doesn’t really matter as long as you work out what you can do at the moment and how you build that up’.

The Alexander Technique teaches that there are correct postures, but these can vary between individuals and pupils should not try to actively achieve particular postures.

P7: It depends where you are and who you are. Like, a comfortable way for me to sit in a chair would not be the same as a comfortable way for you because we’re two different bodies. There will be some principles that will always be true, like for most people you want to get your feet on the floor most of the time.

P7: It’s very paradoxical but a big thing you’ve got to do is almost stop trying to get it right because when we’re trying to get it right we hold tension.

Body Awareness

Participants expressed the need to build awareness of one’s body and patterns of movement.
PT2: Often people with chronic pain are not aware of the way in which they’re moving.

PT1: Getting them maybe to feel themselves what they’re doing in their muscles. How they can feel their- maybe their, their muscles might be particularly overactive and you can feel like quite easily.

P7: It’s really that you become much more kind of literate and tuned in to your body in the environment. I think for most who do Alexander lessons, they just feel more. You just find there is more sensation. And you start to notice ‘Oh my head is forward from my body. Could I let that go?’

**Pacing**

The concept of pacing arose in all pain management approaches except for Alexander Technique.

PT1: You’d want to be trying to encourage a similar level of activity, a similar level of exercises as part of your rehab programme rather than it varying.

P4: You can’t sort of go hell to lever at things even if you are having a good day cause the next day may not be quite so good. So they could encourage you to do – yes you can do one more repetition today.

PT2: I don’t think there’s a great deal wrong from people understanding that that the next day has consequences and it may not be anything to do with a flare-up but be to do with the fact that normally people ache after they’ve done more and they should expect it.

**Cognition & Affect**

The concept of addressing maladaptive cognitions and negative affect arose, to varying degrees, in every treatment approach. Participants described the need to address cognitive biases such as catastrophising and beliefs that pain is an indication of damage, as well as the depression, fear, and anxiety that often occur in people with chronic pain.

PT1: And then giving the patient feedback on [their movement] and how their mood and how their belief systems are all feeding in to maybe this changed habitual movement pattern.

PT2: [...] often trying to stop people from this catastrophic thinking that leads to their low mood – they have a bad day but the way in which they frame that bad day, the way in which they interpret it, makes a big difference to whether they actually start to, if you would like, fail to use their self-management skills.
5.2 Personalisation

PT2: Something that is actually tailored to themselves that can motivate them and also is actually tailored to their specific needs as far as, you know, physical activity, the type of movements they need to do, trying to reduce their levels of fear and anxiety about movement.

5.3 Supportive Functions

Education

Several participants noted the importance of including instruction and reminders about how to self-manage in the technology programme.

PT4: I guess I’m thinking about key messages, you know, like ‘pain doesn’t necessarily mean damage’ and those kind of messages might be useful to have a way of reminding them of those

Detecting Physical Problems

Some participants were eager for the technology to be able to detect physical problems such as muscular tension and movement abnormalities.

PT1: I think there would be an element of being able to detect any sort of biomechanical anomalies.

Tailored Exercise Programme

Most participants expressed the need for exercise programmes that are appropriate for the user.

P2: Everybody has slightly different aches and pains or bits that joints don’t work so well or feel a bit crunchy or whatever, so some technology that would be supporting physical exercise that works for me as an individual.

P6: I work mainly sitting down then the machine could tell me some exercises that would be different than if I work on my feet all day.

Participants emphasized the importance of building the skills in self-management such that people with chronic pain have the knowledge and confidence to make the best decisions for themselves.

PT4: Our advice is always that they determine their level of activity. You know, that’s for them to determine but we can give them reminders and hints and you know like, rules of thumb like maybe you need to drop it by 20% and things like that.

Exercise Demonstration

Most participants thought the inclusion of a figure (e.g. a virtual coach) to demonstrate the exercises would be helpful.

P3: I think I like that idea of where you shadow the coach.
PT4: That would be helpful just as a reminder, an aid memoriam, that would be good.

*Posture Correction*

Obtaining corrective feedback from the technology was a critical function for almost all participants.

P6: […] if you have sensors and if you do anything that it is not right, the machine tells you well you need to do this up, or you need to do this less, or you need to put more here.

PT1: If they were seeing a picture of themselves, how they moved, you would have to support that with sort of verbal explanations of […] how that might be moving incorrectly.

One physiotherapist participant was against any implication that users should aim for a particular posture:

PT4: But provided it’s not giving the message or like, ‘no you shouldn’t move your head. Your hand shouldn’t move that way. It needs to be in this area. You’re not doing it right.’ And all those kind of unhelpful messages.

*Exercise Monitoring*

Participants identified several types of feedback they would find helpful during exercise.

PT4: I guess maybe the time, how much their doing, those kinds of parameters that they can measure in terms seeing that they’re building up their endurance and their stamina, things like that, you know.

*Information Tracking*

Almost all participants spoke about the importance of tracking performance measures as a way of seeing progress.

PT1: I think tracking of progress is absolutely key.

PT4: Well it’s important to keep track of what you’re doing so that you could see any progress or that you might even find that there was an exercise that didn’t suit you and you could perhaps not do that one. […] I think that it would be useful to track how long you’d held a stretch, say, or how many repetitions you’d done.

### 5.4 Encouraging Adherence

*Managing Expectations*

Having appropriate expectations emerged as an important factor to successfully continuing self-management behaviours.
PT4: It would be useful if it could kind of remind them to think about what their priorities are and what they need to be being mindful of during the sessions. Again long those lines of, okay, you’re having a flare-up, is it realistic to expect to do the same amount? Should you reduce it somewhat?

Managing Flare-ups/Setbacks

To support people through these flare-ups and setbacks, participants emphasized the need to manage expectations, as previously discussed, and the need for cognitive reframing, reassurance and encouragement, doing relaxation exercises, and continuing some level of activity.

PT2: By doing some simple relaxation and getting people to continue with some simple activities, because what we don’t want is people just opting out completely.

Forming/Maintaining Habit

Several participants discussed the importance of making exercise habitual for continued adherence to the exercise programme.

PT3: When you talk about learnt behaviour as well and all the psychological aspects of exercise, you want that sort of phenomenon of doing it daily. [...] you can lose momentum very quickly. People go off the boil very quickly with their exercise programmes.

Encouragement/Positivity

For almost all participants, encouragement and focussing on the positive were critical factors in maintaining motivation to continue self-management physical activity.

P4: You know, very very encouraging, saying ‘yes you can do this, just a little bit, and perhaps try a little bit further’ and that sort of thing.

PT3: Strong language is just so important with motivating people to keep that positivity going of, you know, ‘you’re doing great. This is hard for you’, maybe recognising this is hard for you but you’re doing great.

Participants noted that different people respond to different forms of encouragement.

P2: [...] people will vary, won’t they, in how they respond to being told that they should persevere even if they are feeling fed up, in more pain, whatever. And other people will respond better to a more sympathetic approach. [...] I don’t know whether the technology would allow you to find out from a person from an individual which sort of approach works best for them.
Engagement

The use of technology in self-management was seen by some participants as an opportunity to improve adherence through engagement with the technology itself.

PT4: Some people would treat it like a game. I can imagine like younger patients and that might really like it.

PT2: I think the more that you can make something fun and it may also be that you could probably have more than one character in it. [...] I think it would be helpful for some people, not all, but for some people it might be helpful if they have, they could also have somebody doing their exercises sometimes in with them and they can choose an avatar themselves. So a partner or something like that. Anything that actually improves the use of the system. [...] it would be nice sort of then find ways, people can explore ways of actually changing things that maintains their interest.

P1: I think [a virtual coach] would be quite useful because it gives some quite nice interpersonal reaction.

5.5 Visual Representations

Body Image

The concept of body image arose in almost every interview. Participants noted that people with chronic pain often have low opinions of their bodies.

P7: There are people who would already be quite twitchy about seeing their actual size.

Virtual Coach Appearance

Many participants emphasized that the virtual coach should not have the ‘ideal’ body.

P2: I guess the question is whether you think it’s, you know, sometimes they look so impossibly fit, beautiful, unlike you, it could be off-putting I suppose.

P5: [Virtual coach] avatars are always so perfect. So I’d actually be happier with an almost abstract – you know, the data points for the body and detail on the bit that you were working.

User Avatar Appearance

Body image was also a factor in preferences for user avatars.

P7: When I did the avatar exercise at UCH last year [...] it was really nice that it didn’t – it didn’t look like me. You know, I wasn’t thinking ‘oh how’s my hair? How’s my face? Am I fat or thin?’ It took a lot of the emotional charge out of watching yourself.
Several participants mentioned the possible addition of cues emphasizing how to correct their movements or what body areas to focus on.

PT2: So you’re actually highlighting to the patient, you know, ‘you were doing this crouch and this is where you’re going to do the bending and feel the movement.’

**Progress Visualisation**

Opinions varied regarding types of progress visualisations.

P1: I mean you could have a little bar graph at the end of you session. Like this is what you did today and you could look back on, and this is where you were this time last week, this is where you were a month ago, almost like a an overlay to show progression. That might be quite nice.

P2: I know that goal setting is really important so if one of the things that people want to be able to do is gardening then some sort of abstract representation involving a garden would be nice. On the other hand if it’s for somebody to be able to go on a car journey or a train journey or a plane, then something linked to that might be quite nice. […] In other words something that’s linked to their own lifestyle and things that are important to them – their own hobbies. I think a garden would be nice, that’s the sort of thing that would appeal to me.

P7: I think [the garden representation is] quite nice. I think it would vary a lot from person to person. I think that some people would love that idea and other would think ‘oh that’s not for me. I’m not interested.’ But I quite like that idea.