One size fits none! Making affective state a key variable of behaviour change technology for chronic pain

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ABSTRACT

Motivating physical activity in people with chronic pain has challenges over those present in the general population. Physical activity in people with chronic pain is affected by psychological factors such as anxiety and worry about exacerbating pain through movement. Current sensing technologies that can track movement and emotional states and respond with personalised feedback can help promote adherence to a programme of physical activity for this population. Further, tracking people's pain levels, moods, and patterns of activity and giving related feedback can help them to become aware of their needs, ability and limits and hence better tailor their programme of physical activity. It can further help improve people's perception of their own movement and by extension their self-efficacy and confidence. In this paper we discuss an under development interactive system, that incorporates automatic emotion recognition and related feedback to encourage people with chronic pain to increase their physical activity and by extension their quality of life.

Author Keywords

Persuasive technology; behaviour; emotion detection; personal informatics; chronic pain; healthcare

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

People with chronic pain (CP) like many other long-term conditions often experience a radically reduced quality of life and are affected by physical, psychological, and social factors related with pain. CP is pain that persists past healing (around 3 months) after injury or with no identified lesion or pathology [12]. Unlike acute pain, which resolves with healing of injury, CP can continue indefinitely through central nervous system changes. Multidisciplinary pain management programmes use psychological therapy and physiotherapy in an integrated way [7] to enable people with CP to improve their quality of life. However, maintaining physical activity in the long term despite ongoing pain is a challenge; psychological obstacles such worry about exacerbating pain through activity, lack of confidence in movement, frustration at setbacks and anger at slow progress can all have an effect on physical activity behaviour [16]. Although behaviour change applications developed for the general population are successful, they do not address emotional aspects of CP.

We have conducted a multi-faceted set of qualitative studies [15] with physiotherapists and with people with CP to understand emotional needs and barriers and how technology can be designed to motivate and maintain a program of physical activity. Whilst in [15], we report a full analysis of these needs and barriers and a prototype of a first investigation and in [2,3,8,10,14] we demonstrated how general affective states and CP related ones could be detected from non-verbal behaviour, we discuss here how the detection of these emotional states can be used to personalise or tailor behaviour change technology to the needs of people with CP. The targeted behaviour here is the adoption and maintenance of a program of physical activity. Being active can prevent stiffness and weakness, increase feelings of wellbeing, increase confidence in physical capacity and allows people to achieve valued goals [4].

While it is critical to their functioning, that people with CP engage in a programme of physical activity, the main aim is not just to increase the amount of activity they do. Rather, it is to gain confidence in doing activity and to be able to transfer these capabilities to their daily life. Unfortunately, psychological factors associated with CP (e.g. anxiety about movement as a source of increased pain and fear of injury, low confidence in physical capabilities) are critical barriers to physical rehabilitation [1,5] and should be considered when designing technology for people with CP.

Whilst most pain-related psychological factors listed above may be unique to the CP condition, we believe that the lessons learnt from this sensitive case may apply, even if to different degrees, to other conditions and possibly to fitness in general in people with low motor capabilities or low confidence in them.

PHYSICAL REHABILITATION IN CHRONIC PAIN

People with conditions that require physical rehabilitation are generally assisted in their therapy by physiotherapists. However, in CP (and other chronic illnesses), there is a widespread move towards self-management, due in part to the lack of clinical resources. This leads to a changed role for the physiotherapist during the period of contact. Our

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qualitative study shows that a major role of physiotherapists in CP is the transfer of skills such as setting goals, measuring progress, identifying rewards, and increasing awareness of movement. The process of transferring responsibility to manage the CP condition involves a personalised process that encompasses not just the physical capabilities of the patients but also their psychological capabilities. Indeed, given the high variability between people with CP, such a personalised integrated approach is very important

Physiotherapists use non-verbal cues during exercise (such as breathing that indicate level of anxiety towards a particular movement) to decide the amount of support needed. Support can be, for example, in the form of encouragement, exposure to more or less complex movements, and praising. Further, possible exacerbation of pain during or after an exercise needs to be explained or anticipated or it may reinforce beliefs that exercising is not beneficial, even harmful. Personalised interaction with people can determine motivation and adherence. For example, our interviews show that while some people are motivated by physiotherapists pushing them to do more, some feel that their condition and pain is not understood by the physiotherapist who pushes them. Still others feel that physiotherapists should stop them from being overactive.
Unfortunately, limited clinical resources make it difficult to maintain learnt skills in the long term. Hence, a first aim for technology that facilitates the ability to self-manage a physical activity should facilitate the learning of the necessary skills. This can be achieved only through a personalised programme that takes into account both physical and psychological progress. Building on the results from our qualitative study [15], we discuss below some of the desirable skills and how personalisation could help to achieve them.

Setting goals

People with CP have different physical and psychological capabilities and challenges. Further, people are at different stages of a pain management journey [15], which means some of them are just starting out and getting informed about their condition and the importance of doing more activity whereas others have been managing their pain for varying periods of time. People at different stages of the journey may have different levels of confidence in their abilities.

Personalisation of the technology should be based not only on what people can do but also on what they feel they can do to gain confidence. This is very important to reduce the risk of increased pain due to anxiety (e.g., increased muscle tension, decreased inhibition of descending pain pathways). For people at the beginning of the journey, the goal may be exploring their capabilities and increasing confidence in physical activity rather than physical performance. If there are setbacks, personalisation can be used to reset targets to a more achievable level rather than trying to achieve the same level of activity as before the setback.

In [15] we proposed addressing this problem through a sound device designed to provide personalised aural feedback in response to movement. The interval steps between providing feedback were personalised to the range of movement a person felt they could perform and what they felt would be comfortable or challenging. For example, in a stretch forward exercise, often feared by people with CP, if the person's perceived maximum stretch was at 10 degrees, the intervals for feedback were small so that the person could explore his/her capability; compare this to a person that felt they could bend 60 degrees who needed bigger intervals to understand the amount of movement he/she could do and what was a comfortable maximum stretch. In doing this, the device allowed for exploration of capabilities by increasing people's awareness of movement even when the exploration was based on tiny changes.

Measuring progress

It is also possible that people who worry about certain movements causing damage will never push this initial boundary. There are also those people who try too hard and then may have a setback or more pain. Sensor technologies that can detect protective or relaxed behaviour [2,8], just like the physiotherapist, could nudge people into readjusting targets after they feel confident in performing a movement or suggest a readjustment of the new targets if they are too challenging. Physiotherapists gradually expose the CP person to new movements when s/he appears to be not only physically ready but also psychologically ready to try. A technology able to track not only the physical capability of a person but also their psychological state and level of pain can propose new variations of an exercise or new movements on top of a normal routine when the person appears relaxed and is progressing well.

Technology needs to be carefully designed to feedback progress. Sensing the emotional state of people with CP during self-directed exercise sessions can enable technology to better address their needs by understanding what movements people fear the most or worry about and hence avoid consciously or unconsciously. Technology can be personalised to track their reactions to certain activities and either reflect this back to the individual through feedback or help them to work on those areas in a gradual manner by suggesting gentler or alternate exercises or movements. It can also help people to keep track of their activity and how it affects their pain levels and mood hence enhancing self-awareness. Understanding how to pace an activity is also very important especially to transfer that activity to real-life situations. In such cases, progress should be measured both during exercise and in real life situations.

Increasing awareness of movement

Providing all the information recorded by sensors in the form of feedback would result in an overload of information for the user. Different types of awareness can be useful for people with CP. For example, because of fear of pain certain movement patterns become automatic (e.g. arms not moving during walking). Detecting lack of particular movements or increasing awareness of protective behaviour is very important. Protective behaviour (e.g. limping, guarding, hesitating) can cause increased muscle tension and pain or even lack of balance. Various studies (for a review see [2]) show that protective movement can also have an effect on social life. At times, people are unaware of how much they can do because of low confidence. Being aware of their abilities can help with increasing confidence. The system should detect the appearance of protective behaviour, automaticity of it and the fact that they are doing certain movements but are not aware of it. The system then needs to make them aware of this and give prompts or suggest different movements. The amount of feedback can be tailored to the amount of protective behaviour exhibited, as well as to the relative novelty of the exercise and where the person is on the self-management journey. Further, rather than pointing out problems with the movement when anxiety is already high, the technology could suggest a specific exercise to achieve the same end of improving the movement. For example, if the problem is a lack of movement of the arms, the technology could say, "and now let's repeat the movement by swinging the arms."

The literature shows that people with CP may have an altered proprioceptive system, such as a threshold of movement detection, which is lower along certain axes [9] providing a feeling of having performed a larger movement than the one in fact carried out. Providing personalised information about the kinematic characteristics of the movement they are performing (displacement, speed) may also help address anxiety and fear of overdoing.

Motivation and Identifying rewards

People with CP can be intrinsically motivated to be more physical active, and they can feel that doing the activity is its own reward [15]. However, physiotherapists use extrinsic motivation such as praise to reward people to do more physical activity. Further, they can also suggest that the person reward himself/herself with something that gives them pleasure. According to our findings [15], physiotherapists praise people but the amount of praise decreases depending on how confident the person is. Praising is personalised according to how difficult the person finds the movement to avoid patronizing. For rewards, they reflect on identifying what is rewarding, by helping people to focus on pleasurable sensations while exercising. For technology, this means personalised feedback based on using sensors to identify how relaxed the person seems while doing the movement. For example, in our design study described earlier, we reflected the movement as pleasurable auditory feedback and that helped people focus their attention. This auditory feedback can further be personalised to reflect movements people fear and new achievements. Also, new sounds can be used and these can be simple or complex.

Positive moments can be used to enhance pleasure in movement. Tracking positive feelings can be used to enhance awareness of good moments during exercise or at the end of the exercise. In the initial phases of the journey, these can be facilitated through the execution of simple exercises that the person is able to accomplish. During such moments, the technology could prompt the person to be more aware of their own body, breathe better or use mindfulness techniques [6]. In our study, physiotherapists transferred focus to breathing while doing activity [15].

Low mood and setbacks

Detecting the mood of the person may be used to propose a more tailored exercise plan that is more acceptable to the individual's current situation. For example, on a bad day (low mood or severe pain), it is important that the person not be defeated by a plan that feels too hard [15]. The system could start by proposing a modified version of the routine, while not abandoning it since even on bad days it is important to maintain some level of physical activity, preferably with a positive outcome, giving a sense of achievement, sustaining self-esteem and possibly improving mood. If mood changes during physical activity, then the routine may be adapted, possibly proposing a more advanced version of the plan.

DISCUSSION

To achieve the above, it is important that the technology be able to capture at run-time the psychological state of the interacting person. Recently, there has been extensive progress in the design of technology that can automatically detect and track its users' affective states from facial and vocal expressions, body movement [8], and physiological changes (e.g., galvanic skin response). In the case of basic affective expressions, very high performance can be achieved in both acted and naturalistic situations. Automatic detection of emotional states from body movement during physical activity or between physical exercises has also shown very promising results [14]. These results can be improved by taking into account individual idiosyncrasies as discussed in [13]. These capabilities could offer many possibilities for addressing the needs that patients have in order to better adhere to a programme of physical activity; for example, such technologies can support not just recognition of emotional state of the user but also formulate an appropriate response or initiate an appropriate reaction in the technology. For example, if the person shows restlessness or feels anxious, breathing can be suggested before continuing with or during the physical exercise, thus reducing muscle tension and danger of increased pain [15].

To this end, we are developing a fully automated coaching system that can recognize affective non-verbal behaviour related to pain during physical activity sessions. The system aims to provide portable self monitoring and adaptive feedback, as suggested in the behaviour change literature [11], which will augment self-awareness and offer a virtual coaching capability, thus effectuating maintenance of a self-directed programme of physical activity over the long term. This will track patterns associated with affective state, such as anger, low mood, fear and anxiety while doing physical activity and give related feedback to enable people with CP to better understand the relation between their emotional states, body movement strategies and pain levels.

SHORT BIO

Aneesha Singh is a researcher and PhD student at the UCL Interaction Centre. Drawing on her background in life sciences, artificial intelligence and computer systems, her research focuses on designing adaptive systems with affect, specifically to motivate and support people with CP in doing physical activity.

Nadia Berthouze is Reader at the UCL Interaction Centre. Her main area of expertise is the study of body expression as modality for recognising, modulating and measuring human affective states in HCI. She leads a multidisciplinary project on CP rehabilitation (www.emo-pain.ac.uk)

Amanda Williams is Reader and clinical psychologist at University College London and at the Pain Management Centre, National Hospital for Neurology & Neurosurgery, UCLH. She has particular interests in evaluation of psychologically-based treatments; in expression of pain and its interpretation by clinicians; and in pain from torture.

What we hope to discuss at the workshop: We have been studying how to motivate and support physical activity behaviour in people with CP through technology. We aim to discuss if and how personalisation should be aimed at psychological factors alongside physical ones and if these can be addressed during run-time interaction with technology, while exercising, rather than just through self-reflection.

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