GETTING RID OF PAIN-RELATED BEHAVIOUR TO IMPROVE SOCIAL AND SELF PERCEPTION: A TECHNOLOGY-BASED PERSPECTIVE.

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ABSTRACT

People with chronic musculoskeletal pain can experience pain-related fear of physical activity and low confidence in their own motor capabilities. These pain-related emotions and thoughts are often communicated through communicative and protective non-verbal behaviours. Studies in clinical psychology have shown that protective behaviours affect well-being not only physically and psychologically, but also socially. These behaviours appear to be used by others to appraise not just a person's physical state but also to make inferences about their personality traits, with protective pain-related behaviour more negatively evaluated than the communicative behaviour. Unfortunately, people with chronic pain may have difficulty in controlling the triggers of protective behaviour and often are not even aware they exhibit such behaviour. New sensing technology capable of detecting such behaviour or its triggers could be used to support rehabilitation in this regard. In this paper we briefly discuss the above issues and present our approach in developing a rehabilitation system.

1. INTRODUCTION

Chronic musculoskeletal pain (CMP) is affected by physical, psychological, and social factors and multidisciplinary pain management programmes use psychological therapy and physiotherapy in an integrated way [1] to help people with chronic pain improve their quality of life. Continuing a regular programme of physical activity after attending a pain management programme is associated with better long-term outcomes in terms of pain [2][3], work absenteeism [3], and global improvement [2]. However, psychological obstacles such as pain-related fear of activity [4], and lack of confidence in movement [5] prevent many people with CMP from adhering to an exercise programme, with strong negative consequences on their well-being, work and social life [6]. Various studies suggest a strong correlation between negative psychological states and increased disability [7].

Technologies with the ability to sense emotions and to monitor non-verbal behaviour could help people with chronic pain to better manage their condition and better function in both social and work contexts. In this short paper, we first review the literature on pain-related non-verbal behaviours in people with CMP and on how these social signals affect observers' judgements of them and their ability to function in a social context with clear consequences on their well being. We then discuss how current body movement tracking technology [8] could be extended to help people reduce protective pain-related behaviours in the absence of physical danger. We also present preliminary results of our rehabilitation system.

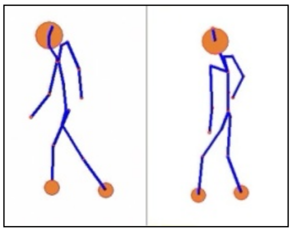

Fig. 1. Examples of non-pain (left) and protective pain-related (right) behavior during walking. The avatars are built from real data collected during motion capture sessions with people with CMP and healthy participants (www.emo-pain.ac.uk) [20].

2. PAIN-RELATED NON-VERBAL BEHAVIOUR AND ITS INTERPREATION BY OTHERS

People with CMP consciously and often unconsciously communicate by non-verbal behaviour that they are in pain or are protecting themselves against more pain when anxiety and fear of movement is high [9]. Behavioural studies [10] define as communicative or protective specific sets of behaviours of CMP patients in various levels of pain. For example, facial expressions such as grimacing communicate with or without intention the presence of pain, with no direct protective effect. By contrast, the main role of protective behaviour (e.g., *guarding, bracing, using support, rubbing, holding)* is to protect one's body from injury or pain increase. Unfortunately, these behaviours are strongly related to pain-related fear [11].

Although called protective behaviour, restriction of movement is often the cause of increased pain, worsens negative emotional states, and effects withdrawal from physical activity. Guarded movement is often produced by strong and prolonged activation of muscles. Fig. 1 shows an example of guarded body movement (right) showing little arm swinging compared to the healthy walker (left). Importantly, the lack of swinging due to increased muscle tension may not only increase pain but also reduce balance control thus exacerbating fear of falling. In addition these movements may instigate empathic behaviour in others whose attempts to help usually discourage activity and focus on pain [12]. Social environment can indeed be a strong influence on the persistence of pain-related behaviour [7].

Pain-related behaviours in chronic pain is at best weakly correlated with the intensity of pain or the seriousness of the condition [13], but observers use behaviours to judge the state of the person. Various studies of heuristics when evaluating others' pain intensity [14][15][16] reveal biases (e.g. gender bias) arising both from the person expressing pain and the observers. However, this is less consistent when evaluating other aspects of pain: people are less likely to use judgment heuristics and more likely to make a thorough analysis of pain-related behaviour when judging the genuineness of pain expressions [14].

Protective pain-related behaviour instead appears to play a more important role when evaluating physical capabilities and personality traits [17]. People showing pain-related protective behaviour were considered less ready to work than people expressing communicative pain-related behaviour, people showing protective pain-related behaviour were rated as less likable and less dependable than people exhibiting communicative pain-related behaviour; those, in turn, are perceived as less likable and less dependable than people not exhibiting any pain-related behaviour.

Whilst observers may infer personality and emotional state from the non-verbal behaviour of a person with CMP, people with CMP are not necessarily aware of their non-verbal behaviour. Data obtained from people performing physical exercise while wearing a motion capture system yielded interesting observations by both people with CMP and clinicians (unpublished data). Many participants showed surprise on seeing their body movement replayed by an avatar (Fig. 1). They showed great interest, meticulously observing their avatar, noticing protective behaviour of which they were unaware, and keen to understand it. For example, one participant was very surprised to observe that her arms, injured many years before, were almost static during walking. People with CMP may be unaware of some pain-related behaviour because it has reached a certain level of automaticity [7][12]. In addition, there is also evidence that such lack of awareness may be due to a dysfunction of the proprioceptive system [18].

Interestingly, the use of avatars to represent body movements proved very interesting for physiotherapists and psychologists who are accustomed to people with CMP very often avoiding looking at themselves in the mirror while doing physical exercises, and refusing to look at videos of themselves as they find them depressing [21][22]. Physiotherapists noted the added benefit that behaviour can be observed free of information that may provoke stereotype-biases [15][16]. The use of avatars, in the home and in healthcare settings, could therefore prove useful in increasing people's awareness of their protective behaviour without the negative impact of real videos.

Given the evidence reported here about how pain-related behaviour affects both the physical condition of the person as well as how they are socially perceived (by both experts and non-experts), it is of particular interest to investigate how the emerging full-body sensing technology could be used to help people with CMP reduce their pain-related behaviour when there is no danger of injury. In the following, we explore the potential of such technology and we briefly report on our current attempt to develop a system to automatically recognize such protective behaviour.

3. BODY MOVEMENT SENSING TECHNOLOGY

Recent advances in sensing technologies and emotion recognition offer new avenues for addressing the needs of people with CMP in terms of self-managing physical activity. For example, such technologies can support automatic emotion recognition [4] and hence could provide tailored psychological support and motivation hence supporting adherence to physical activity and avoidance of pain-related behaviour.

Sensing of pain-related body patterns during self-directed exercise sessions or every day activity can help with understanding what movements or situations that people with CMP fear the most and hence avoid consciously or not. A system can track reactions to certain activities and either feed back to the individual or assist in working on those areas in a gradual manner. Markerless technology (e.g. Kinect) can be used to capture body movements during physical activity and information about them can be provided through avatars such as in Fig.1 or through multi-modal feedback (e.g., sound or vibrotactile). These representations may increase awareness in people without increasing distress as may occur when looking at oneself in a mirror. To decrease habituation and facilitate awareness, body movement (or lack thereof) could be represented only when they are relevant (e.g., occurrence of protective behaviour).

Whilst such technology can be used only during physical activity sessions in a constrained environment, it is also critical that people be supported in their everyday social activity. With accelerometers and vibrotactile sensors becoming cheaper and integrated into clothes [19], such support could be extended outside special sessions. For example, in [19], the authors use accelerometers and vibrotactile sensors to help violin students to learn to maintain the right posture. A vibrotactile signal is applied to the arm of the player when the posture of the elbow is too low or not stretched sufficiently. Continuous tracking and logging of body behaviour during the day could also be used to help people better understand possible physical and emotional triggers of pain-related behaviour outside the home environment and enable them to better manage their condition. Such tracking could be used to increase awareness of pain-related movements during everyday activity and particularly in social contexts, and to help react appropriately, e.g., introducing breathing exercises, reassurance or suggesting alternative movements when guarding behaviour is displayed.

Such systems could be also useful to shed further light into the relationship between protective pain-related behaviour and the physical, psychological and social condition of people with CMP. Current models are built on limited sets of observations and mainly in laboratory settings [7]. Such technology would facilitate longitudinal studies in the wild providing a richer understanding of the problem.

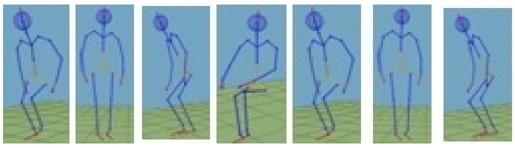

Fig. 2. Example animation of a repeated sit-to-stand exercise [20].

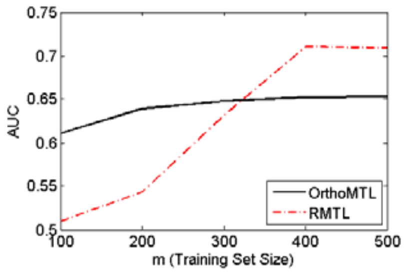

Fig. 3. Automatic recognition performance of guarded behavior through Orthogonal Multi Task Learning (Ortho-MTL) and Regularized Multi Task Learning (RMTL). Area Under the ROC Curve (AUC) values are shown for a variety of training set sizes.

4. TOWARDS A VIRTUAL COACH: AUTOMATIC DETECTION OF PAIN-RELATED BEHAVIOUR

As a first step to achieve the above, we are developing a fully automated coaching system [20][21] that can recognize affective behavioural patterns associated with fear and anxiety while doing physical activity in people with CMP (Fig. 2). This component is part of a more complex system (virtual coach) aimed to provide feedback to help people with CMP better understand the relation between their emotional states, body movement strategies and pain levels. This feedback is based on the literature [5][1][10] and on user studies we have conducted with people with CMP and physiotherapists [21][22]. Our stance is that if the emotional response of the person is taken and we adapt the feedback mechanism more effective support will be provided [23].

The automatic recognition system is based on motion dynamics and muscle activation. Multimodal data of people with CMP undergoing various types of physical activity were collected (Fig. 2). Body movement data were acquired using a full body suit with inertial motion sensors, and used to characterise guarding or hesitant behaviour. The selection of features was based on the literature on automatic emotion recognition from body movement [4][24][25][31][32]. Activity levels of the trapezius and lumbar paraspinal muscles were recorded using wireless electromyography (EMG) as abnormal levels of muscle activity are related to fear avoidance behaviour [11] [26]. 21 people with CMP were recorded.

To improve the performance of the tracking system in terms of personalisation and recognition rate, our model takes into account individual idiosyncrasies. This is done using two approaches: (i) a decoupling approach Orthogonal Multi Task Learning [27] where identity-salient information is determined and factored out and (ii) a Regularized Multi Task Learning based method [28] [29] which identifies the commonalities in the way subjects display the same protective behaviour and individual deviations. Fig. 3 shows the performance of automatic detection of guarded behaviour in people with CMP. The performance was evaluated using leave one person out cross-validation.

A generalised multi indexing version [30] of these algorithms is also being currently tested. This version exploits multiple factors to improve the recognition performances through further personalization of the system to the individual person and to nuances of protective behaviour. Further directions could consider unsupervised learning of such expressions to address the sparsity of the data and the possible different categories of such behaviour [33]. Cross-cultural differences should be also taken into account as they play an important role in the way we express emotions [34] and how socially acceptable this is.

5. CONCLUSIONS

This paper discusses the importance and the implications of pain-related body movement as a social signal. Evidence shows that this behavior is not only detrimental to the well-being of the person with CMP but also has a strong impact at the inter-personal level: observers cannot only reinforce anxiety and pain-related behavior by responding empathically to such behavior, they are also likely to use such behavior to assign negative personality traits with possible social consequences. In this respect, emerging full-body technologies endowed with the ability to detect emotion and pain-related behavior can serve a useful dual role: (a) they can improve awareness of such behaviors in people with CMP so that they can limit their occurrence and associated negative impact; (b) through monitoring, feedback and psychological support, they can help people with CMP deal with the triggers of pain-related protective behavior. Our initial results on the automatic detection of protective behavior provide the foundation for building such technology. These systems could help to further understand the relationship between pain-related behavior and physical, psychological and social factors.

6. ACKNOWLEDGMENT

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