The affective body argument in technology design

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ABSTRACT
In this keynote, I argue that the affective body is underused in the design of interactive technology despite what it has to offer. Whilst the literature shows it to be a powerful affective communication channel, it is often ignored in favor of the more commonly studied facial and vocal expression modalities. This is despite it being as informative and in some situations even more reliable than the other affective channels. In addition, due to the proliferation of increasingly cheaper and ubiquitous movement sensing technologies, the regulatory affective functions of the body could open new possibilities in various application areas. In this paper, after presenting a brief summary of the opportunities that the affective body offers to technology designers, I will use the case of physical rehabilitation to discuss how its use could lead to interesting new solutions and more effective therapies.

CCS Concepts
• Human-Centered Computing

Keywords
Affective body expressions, automatic recognition, touch behavior, muscle activity, embodied affect, physical rehabilitation

1. INTRODUCTION
With the decreasing cost of full body-sensing technology and its ubiquity, body expression is gaining increasing attention as affective channel but possibly not at the speed and to the extent it deserves. When designing affective-aware interactive technology, facial and vocal expressions are still the affective channel of choice to capture how the user feels. This is surprising given the opportunity that the body offers to capture and steer the user's emotional experience. In this keynote, I will briefly summarise these opportunities and then use the case of self-directed physical rehabilitation to argue that this modality should be more fully exploited.

2. BODY AS AN AFFECTIVE MODALITY
A growing body of work in psychology has shown that we communicate and read other people's feelings not just from their faces or the tone of their voices but also and often more reliably from their body (e.g., [1][2]). Aviezer et al. has shown that in the case of strong emotions, body expressions are even more revealing and reliable than facial expressions when judging how a person feels [3]. De Gelder [4] also argues that body expressions tell us not just how somebody feels but also inform us of what the person is ready to do in response to the cause of the emotional arousal, i.e., what is also referred to in psychology as "action tendency".

Pioneering studies on body expressions as a means to perceive or convey emotions show the existence of clear body configurational and dynamical patterns characterizing each specific emotional state or even the more broad affective dimensions. By examining both the psychology and affective computing literature, Kleinsmith et al. [5] provide an in depth review of such patterns. Cross-cultural studies have shown the universality of the majority of these patterns even though cultural differences may still exist in the way affective expressions are interpreted [6][7] and used (see [5][8] for a review).

Building on this body of literature, the affective computing community has investigated the possibility to automatically discriminate between the different affective states and affective dimensions conveyed by body expressions in both acted (e.g., [9-13]) and, more recently, naturalistic [14][15] settings. These studies have led to automatic recognition performances that are comparable to the ones obtained for facial and vocal expressions and with a similar level of agreement seen between human observers. The work by Kleinsmith et al. [14] and subsequently by Savva et al. [15] shows the potential of this modality for personalizing full body computer games at runtime according to the emotional engagement of the player (e.g., [16]). The work by Griffin et al. [17] and Niewiadomski et al. [18] shows how the communicative power of body expressions is not limited just to basic emotions but also helps to discriminate between the emotional quality and intensity of other everyday expressions such as laughter types.

Most of this work on body expressions analysis has been limited to what is visible of the body, even when motion sensors rather than video cameras have been used. More recently, researchers are investigating the specific body muscle activation patterns that characterize each emotional expression. Huis in't Veld et al. [19][20] proposed what they call BACS (Body action Coding System) as a first step to build an equivalent of the FACs developed by Ekman et al. [21]. They found specific body muscle activation patterns for anger and fear.

In the last years we have also been witnessing increased attention to the study of affective touch behaviour as an extension of body behavior, sharing with the latter very similar discriminative features. Again, the recognition rates are very robust even in naturalistic settings as presented by Gao et al. [22] in the context of smartphone-based computer games.

3. THE OTHER SIDE OF THE BODY
Beyond being a powerful communication modality, body expressions also affect how one feels. Various studies in psychology (see [23][24] for a review) have shown that the way we stand and move biases our emotional state towards the emotion portrayed by the enacted body expression. The work of Carney et al. [25] shows how these regulatory properties of body expressions are based on the regulation of hormones production triggered by the enactment of the body expression. Cuddy et al. [24] also argue however that there are various factors that need to be taken into account for this mechanism to work.

Building on this literature, Bianchi-Berthouze [23] has put forward a model for technology designers to directly leverage the body to drive the emotional experience of a person during gaming. Isbister et al. [26] have explored the possibility offered by full body sensing technology to regulate confidence in children learning math

through full body games. De Rooij et al. [27] have investigated how to exploit full-body sensing technology to hack the function of motor regulation in the context of creativity. Atkinson et al. [28] explore how touch behaviour on touch-based displays can contribute not only to a better understanding of some of the properties of textiles but also to the pleasurable experience of interacting with them. Petreca et al. [29] also lend support to the importance of affective body movement during the creative process of textile design by showing how textile designers normally engage body movements to generate and experience design ideas.

4. THE AFFECTIVE BODY IN PHYSICAL REHABILITATION

A particular area that is of interest to me is technology for self-directed physical rehabilitation. The development of such technology is of critical importance given the increasing number of people that live with chronic conditions (e.g., stroke, chronic pain, diabetes) causing a huge demand on clinical resources that cannot be fulfilled by the National Health Service. Full body sensing technology, especially in the context of computer games, is seen as a way to address this problem by providing effective and more accessible physical rehabilitation therapy.

Unfortunately, most of the work in this area has a limited perspective on the design of such technology and simply uses the clinical model of physical rehabilitation to drive technology design for the home. This means that the use of body sensing and feedback technology is limited to providing more accurate measurements of people's movement performances and physical progress, and tailoring run-time feedback to drive movement [30]. The approach simply transforms a physiotherapy session into a more engaging exergame session personalized to patient's physical needs. Whilst such use of technology offers powerful and accessible opportunities for doing physical rehabilitation in one's own homes, efficacy is generally evaluated in controlled lab studies in the presence of researchers and physiotherapists.

Unfortunately, in real-life situations, physiotherapists are not generally present in the person's home and self-management is recommended for chronic condition. Emotions other than boredom and frustration surface in these situations: fear of injury, anxiety of increasing pain, lack of confidence [31], lack of skills and confidence in tailoring the physiotherapy parameters are just a few examples of these emotional barriers. Clinical [32] and HCI literature [33] shows that these emotional barriers lead to reduced adherence to programs of physical activity in the absence of support provided by clinicians. This reduced physical activity causes further body deterioration and reduces confidence in functioning.

The design of such technology could benefit from the opportunities offered by the affective body summarized in the previous section. In the Emo&Pain project (www.emo-pain.ac.uk), we investigated the possibilities of automatically sensing how people feel as they engage in movement and providing run-time personalized support to address their psychological needs (and not just the physical ones). In Olugbade et al. [34][35] we have shown how wearable body sensing technology embedded with motion and muscle activity sensors could be used to automatically detect perceived pain levels or anticipation of pain and emotional distress of a person as they perform physical exercise. In addition to continuous monitoring of emotional states, the monitoring of the body action tendency in response to the emotional state can also foster a better understanding of the person's coping ability and strategies and thus what support should be provided. Automatic detection of hesitation and protective movements in response to anxiety or fear of injury [36] allows the tailoring of the difficulty level of the activities that the person is able to physically or psychologically undertake and slowly build from there. In related studies [37], people with chronic pain reported that they are often unaware of their anxiety until their body tightened so much that their pain increases. They also reported being often unaware of using protective behaviour [38] which can lead to further deterioration of one's body due to overuse of some body parts and underuse of others. In addition, through the affective body loop, guarding behaviour may lead to a reinforcement of negative emotions, low efficacy and also indirectly to social isolation [39]. People with chronic pain saw in affective(body)-aware technology the possibility of better functioning [37].

In addition to automatic emotion recognition capabilities for situated physical rehabilitation (e.g., Kinect-based technology), the integration of movement and EMG sensors in clothes make it feasible to monitor a person during everyday activity. The work by Singh et al. [40] has shown that most of self-directed rehabilitation does not occur in situated physiotherapy sessions but during every day functioning, which is also the target of physical rehabilitation. Indeed in many chronic conditions, the aim of physical rehabilitation is not to provide a cure but to support the person affected by the condition in recovering or maintaining their functional capabilities or even just in slowing down the physical decline. Unfortunately, people often struggle to translate gains from physical rehabilitation sessions to everyday functioning [33]. Singh et al. [40] designed a wearable device able to capture not just physical, but also psychological needs and showed how such a device could embed physical rehabilitation directly into every day functioning (e.g., while loading the washing machine). Their results also showed how such device could help identify needs in everyday life and set exercise sessions specifically tailored to develop the physical and psychological capabilities needed by such activity.

Beyond personalized support based on automatic affect detection, the regulatory properties of body expressions can provide a great opportunity in this context but they are still under explored. In Singh et al. [40], the authors showed that the run-time sonification of body movement (i.e., mapping quality of movement into sound) tailored to the psychological needs of the person led to increased awareness of one's movement capability, increased confidence in moving and increased performance. In addition, to enhance the perception of one's body capabilities, studies have also shown how the altering of these perceptions could be beneficial. Tajadura-Jimenez et al. [41] altered the sound made by one's footsteps at run-time to make them appear as if they were made by a lighter body. This alteration made people feel and behave as if they were lighter, felt more positive and perceive movement as easier to perform. By acting on the dynamic representations of our body that we build from the feedback we receive in response to our physical actions and by exploiting the regulatory function of body expressions, it is possible to help people to form a more positive relationship with their own body. Although Tajadura-Jimenez et al. [42] explored these possibilities with healthy participants, their work showed the potential for new therapy in many conditions beyond physical rehabilitation.

5. CONCLUSIONS

The aim of this brief review was to highlight the opportunities that the affective body offers to technology designers and mainly to the users of such technology. It further aimed to direct attention to this modality often neglected in favor of the more common and exploited ones.

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