Interoceptive Awareness: Metaphorical Mapping & Bodily Experiences for Insourcing Tuning

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The growing HCI interest in the role of the body and bodily experiences in design has led to new interactive technologies or design methods harnessing them. Despite this interest, interoceptive awareness has been limitedly explored in HCI research. This paper offers a reflection on technologies and design methods supporting interoceptive awareness that I have explored and designed with my research group, with a focus on how these may support *insourcing tuning*.

CCS CONCEPTS • Human-centered computing ~ Human computer interaction (HCI)

Additional Keywords and Phrases: Interoceptive awareness, Interactive technologies, Emotional awareness and regulation, Mindfulness, Design methods, Insourcing tuning

1 INTRODUCTION

The last decade has shown an increasing HCI interest in the role of human body in interaction design [1][2][16][17][19] and in particular bodily experiences that may be leveraged through, and for design. These have been explored through both traditional display technologies [6][7][15] or more novel ones integrating biosensors and actuators [38]. Such technologies have focused mostly on user experience but also on designers' experiences and how these too could be harnessed in design [24][28][29]. In this paper, I reflect on technologies and design methods supporting bodily awareness in general and interoceptive awareness in particular, that I have explored and designed with my research group. In particular, this paper offers a reflection on how these technologies and design methods support *insourcing tuning*.

2 BACKGROUND

This section introduces relevant conceptual terms for inbodied interaction and its framework to advance the concept of insourcing tunning. It continues with a brief overview of research prototypes for mindful meditation, emotional awareness and regulation, as well as novel design methods that leverage bodily and particularly interoceptive awareness.

2.1 Context

The concept of *inbodied interaction* has been introduced to complement the embodied interaction and to address the latter's limited focus on the body per sei [2][30][32][33][34][35]. Schraefel and colleagues highlighted the importance of bodily internal processes, and proposed a model for inbodied interaction around five basic processes of movement, eat, engage, cogitate and sleep, underpinned by volitional and physical components [36]. The framework also articulates four elements characterizing the surrounding environment impacting on our bodily experiences such as air, light, gravity and microbiome. Besides these five basic process and four external elements, Schraefel and Hekler [31] also noted in this framework two additional aspect: temporal and contextual ones. Schraefel and colleagues [30] have further highlighted the importance of *insourcing,* as one end point of a continuum complementing outsourcing, at the other end. They suggested insourcing as a useful design principle for prompting users to rely less on tracked data as an external source of information, and more on bodily feelings related to the in5 basic processes of inbodied interaction. In this context, authors also suggested interoceptive awareness, as a key aspect facilitating insourcing as well as *tuning*. The latter has been defined as a volitional process of "becoming resonant and harmonic with oneself" particularly one's non volitional inbodied processes, which in turn supports healthy adaptation in different contexts [31].

While useful, this definition does not explicitly articulate what such target harmonic states are and how resonance can be achieved. To address this, it may be useful thinking at tuning, as an alignment of two phenomena and how by relating to each other through such alignment they can work together [31] For instance, we can draw similarities between this framing of tuning and entrainment used for instance to support deeper mindfulness states through binaural beats [25]. In this case, the two phenomena are the rhythmic beats and their matching brain frequencies as suggested in previous work on binaural entrainment for meditation [18].

2.2 Technologies for Mindfulness Meditation

Meditation is a key practice for emotional wellbeing and health [25] that highlights the mind-body interconnectedness. Through its focus on attention regulation, mindfulness meditation supports increased awareness of both external world as well as internal experiences reflected in thoughts, emotions or sensations.

With my collaborators, we run an initial study with 24 expert meditators that helped identify specific sensorial experiences marking specific key points of meditation sessions or meditation states such as grounding oneself that is usually experienced as a downwards movement through one's upper body, becoming mindful which is characterized by an opposite upwards movement often with sensations of warmth in the tummy, being mindful marked by a state of balance, while mind-wandering tends to be associated with loss of bodily awareness [4]. While not exclusive, sensory processes are in fact part of inbodied interaction. We further leveraged these embodied metaphors of meditation states and employed a magic machine methodology to design WarmMind, a prototype integrating heat actuators for providing on body thermal-based neurofeedback during focus attention mediation [5]. We explored the use of WarmMind through a study with 10 participants where we compared this interoceptive interaction with a neurofeedback system providing real time aural metaphors for mapping key meditation states, i.e., heavy rain for mind wandering state and river /birdsong for mindfulness state.

We defined interoceptive interaction as "*interaction with bodily data through interoceptive senses aimed to bring the attention inwards to increase awareness of bodily states*" [5], p 18]. We followed with semi-structured interviews to understand participants' perception and understanding of the two neurofeedback modalities, i.e., aural and thermal patterns and their mappings to meditation states. A key outcome of this study was that the ambiguous

thermal feedback, although delivered by heat pads placed on, rather than inside the body, it was still experienced by participants as coming from inside the body. WarmMind prototype has illustrated what we called interoceptive interaction. Despite the placement of the heating actuators on the skin of the upper body, yet, they were perceived as originating from within the body, and arguably due to the interoceptive sense of thermoception. Thermoception sense is triggered by thermoreceptors in the skin or viscera responding to changes in body temperature [21].

2.3 Technologies for Emotional Awareness and Regulation

We have also done a body of work on affective technologies. Emotional awareness and regulation are key skills for emotional wellbeing and affective health [3][13] and a growing body of HCI work has focused on such technologies over the last decade [19][23]. The integration of biosensors such as those measuring galvanic skin response or heart rate with visual or haptic actuators has led to real time biofeedback interactive systems whose findings have shown to lead to increased emotional awareness [22]. This could rely on increased awareness of the changes in the autonomous nervous system signaling changes in physiological arousal. Through a material exploration of smart materials [37], we designed 6 wearable technologies providing real-time visual and haptic biofeedback on such changes [39]. The exploration of these interfaces with 12 users in everyday life settings, has shown that these interfaces successfully support emotion identification, attribution, and regulation [41], and that users would also benefit from personalizing them [27][40]. These findings particularly emphasize the support for affective chronometry or the awareness of the temporal unfolding of emotional responses, as another potential window into the interoceptive awareness of physiological changes underpinning emotional responses.

2.4 Design Methods Emphasizing the Body

HCI interest in novel design methods focusing on bodily awareness has started to emerge. While external senses have been extensively leveraged in HCI, the interest in the latter has been reflected for instance in somaestethics [1] or microphenomenology approaches to design [19][19]. Somadesign approach has been used for example to support designers' visceral understanding of biodata through haptic or sound actuators, so that it can better harnessed in design of affective interfaces [1]. Other design methods rely on developing empathy for the lived experiences of those living for instance with depression. For this, we developed ManneqKit [26], a kinesthetic design tool describing bodily postures of depression alongside poignant vignettes, whose findings indicate its value of eliciting empathy. The postures have been co-designed with therapists capturing the essence of depression experience albeit in metaphorical way. We would argue however that they can still draw from the mimicry of postures, supporting those interacting with the ManneqKit to experience the depicted feelings of depression, that is commonly associated with impairments of interoception [14]. Indeed, consistent findings have shown that people living with major or moderate depression have significant interoceptive deficits of heartbeat perception when compared to non depressed people [8]. ManneqKit experience builds more on the proprioception or awareness of the body and limbs in space rather than on interoception, with the former being key to the experience of bodily movement, one of the five processes within inbodied interaction framework [2]. Beside movement, emotional experiences and their bodily sensations also reflect aspects of inbodied interaction.

Given the emphasise on eat, as another one of the five processes within the inbodied interaction framework [2], I now briefly describe material food probes that can be positioned within the growing body of HCI work on human-food interaction [9][10][11][12]. Material food probes integrate 3D food printer with co-designed flavors in order to inspire the design of novel food experiences. They draw from material qualities of 3D printed food such as those

of eliciting taste and smell used in order to communicate and regulate emotions within intimate relationships. These probes leverage richer, multisensory experiences and their personalization support strong user engagement.

3 REFLECTION: HOW THESE TECHNOLOGIES MAY SUPPORT INBODIED INTERACTION & INSOURCING TUNNING

I now reflect on *insourcing tuning* and how the technologies and design methods described above may support inbodied interaction and in particular insourcing tunning [31]. First, let's start with a working definition of insourcing tuning which I propose as being a regulatory process through which people volitionally harmonize internal bodily systems to some target states. The target states can be communicated through external senses such as vision or hearing like we have in the case of bio- or neuro-feedback systems illustrated above. However, when target states are perceived as also originating from the body, they may particularly support tuning. Insourcing tuning can be done for healthy purposes, as we have seen in meditation and affective technologies, as well as for better communication and empathy like we have seen in novel design methods such as food probes and ManneqKit.

Key for tunning appears to be the metaphorical mapping, aligning bodily states such as mindfulness ones in case of WarmMind [5] or those representing changes in physiological arousal to visual or haptic interfaces. Particularly important is how interoceptive senses such as thermoception rather than external ones are better positioned to support interoceptive awareness. A similar mapping is employed in somadesign and the ManneqKit, leveraging again metaphorical representations of bodily experiences through visual, haptic or posture modalities. The latter indicates the value of proprioception, especially for the process of movement, while the other example touches upon the processes of engage and eat [30]. These design methods tend to be sensorially rich, eliciting engagement through more modalities, beyond the predominant audio-visual focus. We have seen the emphasis on taste and smell through material food probes, and haptics for the other methods. Haptics have also been leveraged both by the WarmMind and our affective interfaces. Finally, most of these interfaces and design methods have also been developed through design approaches emphasing both the body, but also physical and aesthetic qualities of the design materials, from material exploration to magic machine approaches. These key points may be used to frame future design guidelines and methods for inbodied interaction.

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