Exploring Material Metaphors to Design Sensorial Wearables for Body Transformation Experiences

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Neuroscientific and HCI research has shown that people's body perceptions are not fixed, but are continuously updated through sensory and motor signals. Our research focuses on investigating how sound, haptic, and movement signals can be used to induce illusions of one's body changing, or Body Transformation Experiences. In our recent work, we have started to look at the potential of designing wearables integrating sound and haptic stimulation using "material metaphors" to tackle and transform different body perceptions. To this workshop, we will contribute to the theme of "material enabling transformation" a prototype, "Soniband" which sonifies body movement by employing material metaphors with the aim of linking sounds (e.g. water) to body perceptions (e.g. being fluid and moving faster). We will also contribute a method, Sensory Bodystorming, based on material sensory probes, for exploring the design space for body transformation wearables. We will share insights from studies using Soniband with various populations susceptible to body concerns, including people who are physically inactive and professional dancers in terms of effects on body perceptions, body movement, and emotion. We are interested in discussing other potential uses of materials for enabling transformations and in future designs aimed at supporting people's health and promoting behavior change.

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1 INTRODUCTION

Our bodies are the interface through which we perceive and interact with the world around us. Our perceptions of our body's appearance, configuration, and motor abilities shape our movements and interactions with objects and other people [5]. Critically, neuroscientific and HCI research has shown that these body perceptions are not fixed, but are continuously updated through sensory and motor signals [2, 13, 15]. By altering immediate bodily sensory feedback, perceptual illusions of one's body changing, or Body Transformation Experiences, can be engineered to create illusions such as having longer arms [7, 31], a larger or smaller body [19, 23, 34] or enhanced body capabilities [10, 11]. The

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Fig. 1. **SoniBand**'s technical elements and an example of wear with an angular movement sequence that would activate it.

impact of such Body Transformation Experiences extends beyond entertainment and can lead to changes in motor [24, 27] and social behavior [1, 4, 14], emotional state [10, 24], body satisfaction [20], and self-identity [26, 28, 32], also opening possibilities for applications in sports and health, wearable and remote robotic devices, virtual avatars, and new art forms [6, 16–18, 21, 25]. Our research focuses on investigating how sound, haptic and movement signals can be used to induce illusions of one's body changing, or Body Transformation Experiences.

We constantly produce sounds as our bodies touch objects and surfaces, for instance when we touch a table with our hand, drop a ball or walk on a wooden floor. These sounds can significantly influence our perception of materiality, as well as the mental representations of our body. Our studies have shown that modifying the sound feedback produced during touch interactions can lead to changes in the perceived length of body parts. For example, hearing the sounds produced by tapping a surface from a greater distance can create the illusion of a longer arm and impact subsequent arm movements [27, 31]. We also found that altering the frequency spectra of the sounds produced when walking on a surface can create the illusion of a lighter body, which in turn affects our gait and emotional state [24]; this illusion is enhanced when adding a lemon scent [3]. Our studies using gesture-sound interactive systems have also highlighted the potential to influence people's feelings about their bodies, movement awareness, and behavior [10–12]. In our recent work we have started to look at the potential of designing sound and haptic stimulation using "material metaphors" to tackle and transform different body perceptions. Our exploratory studies on haptic "material metaphors" showed potential in employing top-down mechanisms to link materials (e.g., rocks) to body perceptions (e.g., being heavy, strong) to trigger changes in body perception and emotion [8, 9, 29, 30]. In our recent works we have also been exploring sonic "material metaphors" [11, 12, 28]. To this workshop, we will contribute a prototype, "Soniband" which sonifies body movement by employing material metaphors with the aim of linking sounds (e.g. water) to body perceptions (e.g. being fluid and moving faster) [12].

1.1 Soniband: a Wearable Device that Sonifies Body Movement with Material Metaphors

The SoniBand is a wearable device that is designed to provide real-time sonification of movement angles through a variety of movement-generated sounds. The device is embedded in a fabric patch within a bracelet, and can be worn on different parts of the body such as the arm, leg, or neck. The SoniBand incorporates a 9-axis Inertial Motion Unit (IMU) embedded in a BITalino R-IoT. The movement angle data is wirelessly transmitted to a Raspberry Pi Zero, which can be controlled through a web browser on a smartphone, see Figure 1. SoniBand includes different sound conditions, some of which build on material metaphors. For example, "water", a sound of continuous running water throughout the movement, with an added "splash" sound of hitting water just after the start/end position of the calibrated movement;

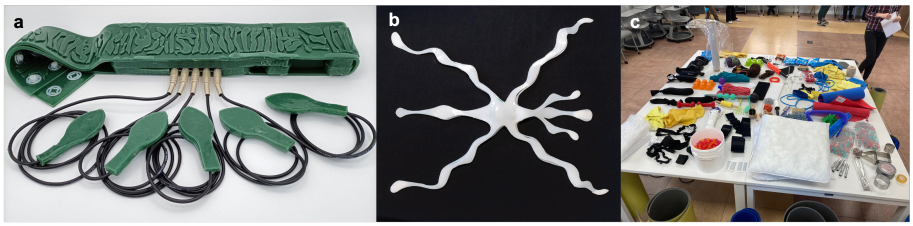

Fig. 2. (a) Vibrant wearable version, (b) vibrant object version, (c) material for body transformation experiences

or the discrete "mechanical" sound, that emulates rusty gears, and that plays throughout the movement and changes its frequency gradually as it gets near the start/end position of the calibrated movement [12].

SoniBand has been used in different studies with people who are physically inactive [10–12]. These people experience psychological and emotional barriers related to their body perceptions (such as tiredness, not feeling able or agile) that prevent adherence to physical activity. Soniband has been used in studies with particular types of exercises (e.g., leg lift, thigh stretch, squat, and walking, etc.), where we found sound and movement combinations that can impact feelings about the body (e.g., feeling stronger), the movement (e.g. faster movements) and emotion (e.g., feeling in comfort, happier). Sound also affects movement behavior (e.g., increasing acceleration) and proprioceptive awareness [10, 11]. In addition, we conducted two qualitative studies with physically active and inactive populations. The aim of these studies was two-fold. First, elucidating the effects that particular metaphorical sonifications' qualities and characteristics have on people's perception of their own body and their PA. Second, understanding how the observed effects may be specific to physically inactive (or active) population using the SoniBand prototype for several days in different contexts. The results showed that the properties of movement sonifications are connected to specific body feelings and aspects of physical activity, but the effects vary depending on the physical activity-level of the population [12].

Recently, we have also explored the use of SoniBand with professional dancers who experience negative body perceptions. The use of SoniBand affected on how individuals perceived their body size, weight, capabilities, and overall body awareness. Furthermore, it influenced the speed, fluidity, weight, and endurance of movement, as well as promoted specific types of movements. The use of SoniBand was associated with positive emotional experiences, such as pleasure, joy, feelings of freedom, amusement, curiosity, and empowerment.

1.2 Sensory Bodystorming: A Method to Open the Design Space of Material-enabled Body-based Multisensory Experiences

We will also bring to the workshop a demonstration of the embodied design-based methods that we employ to open up the design space of material-enabled body-based multisensory experiences [22]. In particular, we will demonstrate our use of Sensory Bodystorming [33] as method to sensitise participants (often without technical expertise) and to generate ideas for designing rich sensory experiences. The method involves physically engaging with various sensorial stimuli, prompted by sensory probes with diverse material properties - such as different shapes, weights, and textures (e.g., soft/hard/rough/elastic) selected to produce qualitatively different sensorial stimuli. Such probes are often craft-material (e.g. bubble wrap, carton, rubber bands), or off-the-shelf objects, (e.g. sponges, scratchers, marbles). By engaging in specific situations and aspects relevant to the target design activity, participants can explore the potential of different sensory stimuli and imagine future prototypes. Often, facilitation is necessary to help participants fully leverage the performative nature of the probes, and to translate generated ideas into concrete design concepts.

In our group, we have employed Sensory Bodystorming in several projects. One example is in explorations with people how sensory feedback could help activate them physically [22]. Through the use of Sensory Bodystorming, participants explored what type of sensory input would work best for them to get physically activated, ultimately resulting in the design of Vibrants, two haptic actuation devices (a wearable version, see Figure 2, and an object version, see Figure 2) that provide vibrotactile feedback. The wearable version provides linear feedback on body movement (angle changes) that activates bottom-to-top or top-to-down sequences respectively during upward and downward movements. The object version is made of silicon and has a simpler array of vibrating mini-motor discs, controlled through an app. The vibrotactile feedback can be configured in various patterns, speeds, and frequencies.

In the workshop, we will bring a selection of our sensory probes and will facilitate a short mock-up ideation session, so participants get sensitised to the potential of the probes to elicit thinking about, feeling and ideating different sensory inputs.

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