The Ilinx Garment: Whole-body tactile experience in a multisensorial art installation

Valerie Lamontagne, Maurizio Martinucci and Chris Salter
Concordia University

Ian Hattwick, Ivan Franco, Marcello Giordano, Deborah Egloff, and Marcelo M. Wanderley
Input Devices and Music Interaction Lab, McGill University
Centre for Interdisciplinary Research in Music Media and Technology

Montreal, Quebec, Canada

Abstract

Utilizing the tactile sensory channel as a key sensory modality in a full body, cross media artistic installation presents unique challenges. In this paper we describe our experiences with the design and utilization of garments containing embedded sensors and vibrotactile actuators. We follow the garments from their conception through their use in a artistic installation experienced by over 300 visitors. In particular, we focus on the relationship between touch, hearing, and sight – both in the technological implementation as well as the artistic conception.

Keywords

Multimodal display, haptics, wearable electronics, responsive environment, first person data, sensory participation

Introduction

This paper presents the dual outcomes of a research-creation project whose focus was developing a system for generating tactile signals in an artistic experience. The first outcome we will describe is the design and construction of garments containing embedded sensors and vibrotactile actuators as well as a wireless connection to a central server which transmits performance instructions. The second outcome we will describe is the artistic work which utilized these garments, a performative environment incorporating visual, aural, and tactile elements.

Participants

The team involved in this project consisted of artists, clothing designers, electronics designers, and haptic researchers. As in any collaborative interdisciplinary project the outcome depended upon a careful balancing of the multiple interests and priorities of the participants as well as the practical constraints of the project structure. Throughout this paper we will touch upon the disciplines of the different collaborators and the ways in which their contribution affected the creation of the garments. While much of our discussion will be focused on the characteristics of the tactile actuators which are embedded in the garments, we will also touch upon general issues raised by the inclusion of a garment of this kind worn by the general public (rather than a trained model or performer) within the context of an artistic installation.

Figure 1: Promotional Image for Ilinx. ©Chris Salter

Ilinx

'Ilinx' is a performative environment for the general public provoking an intense bodily experience that blurs the senses of sight, sound and touch. A promotional image for the work appears in figure 1. In the environment, a group of four visitors at a time wear specially designed garments. These wearables are outfitted with various sensing and actuating devices that enable visitors to interface with the performance space. During the event, a ritualistic progression which lasts approximately twenty minutes, the natural continuum between sound and vibration, vision and feeling becomes increasingly blurred, extending and stretching the body boundaries beyond the realm of everyday experience.

The project is partially inspired by work in the area of what is called sensory substitution – the replacement of one sensory input (vision, hearing, touch, taste or smell) by another, while preserving some of the key functions of the original sense. The term "ilinx" (Greek for whirlpool), however, comes from the French sociologist Roger Caillois and describes play that creates a temporary but profound disruption of perception as is common in experiences of vertigo, dizziness, or disorienting changes of speed, direction or the body's sense in space – "an attempt to momentarily destroy the stability of perception and inflict a kind of voluptuous panic upon an otherwise lucid mind." [2]

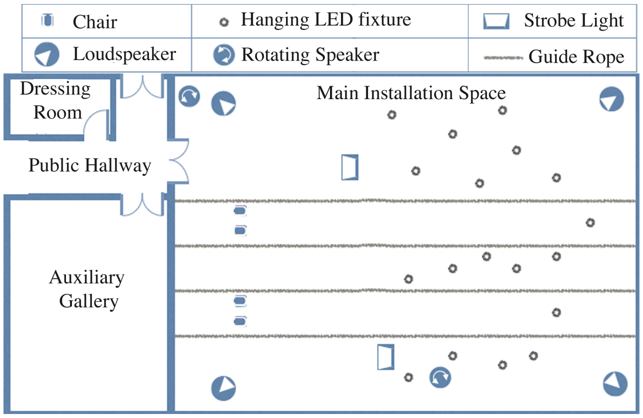

Figure 2: Diagram of the Ilinx installation space.

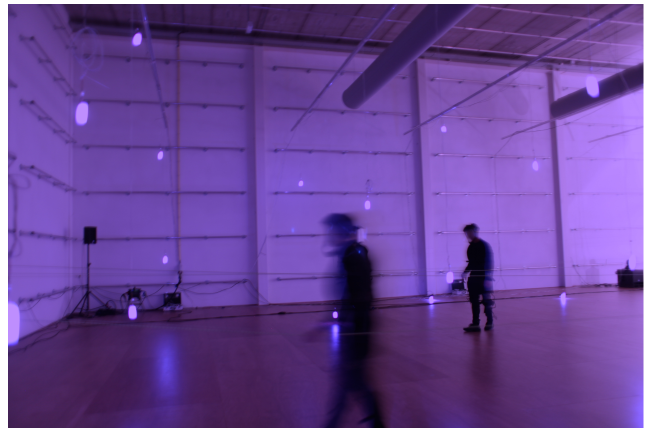

Figure 3: Participants in the Ilinx installation. ©Chris Salter

The garments worn by the visitors consist of a jacket, a pair of leggings, and a helmet with a semi-opaque full-face mask. The helmet serves to limit the visitors' vision to the perception of areas of light. Once garbed, participants are led into the main installation space and seated in chairs, as shown in figure 2.

The work is structured into two sections. The first section begins with a simple vibration pulse and corresponding sound. The sound is generated by a combination of a quadraphonic full-range speaker system as well as a pair of directional speakers each mounted on a rotating gimble. Throughout the first section new sonic material is introduced. A loud bell and the appearance of faint lights in the distance signal the beginning of the second section. In this section, visitors are able to stand and take hold of guide-ropes which allow them to safely explore the space. As they walk into the space they pass through a field of suspended LEDs as seen in figure 3. Towards the end of the second section bright flashes from a pair of strobe lights contrast with the faint illumination of the suspended LEDs, and build towards a gradual climax. After a final combination of a loud sound, flash of light, and set of vibrations the piece comes to an end. At that point the visitors wait where they are for a guide to come and lead them out of the space.

Background

Although there are numerous examples of multi-sensorial artworks which incorporate tactile stimuli (normally in the realm of "tactile audio"), the implementation and conceptualization of a system for generating these stimuli remains a challenge. [15, 6, 17] Conceptually the tactile sensory channel is very different from the aural and visual channels. Not only are tactile sensory receptors located throughout the human body but there are also multiple types of tactile receptors optimized for different kinds of stimuli.

The Haptic Channel

Haptics is an umbrella term which encompasses both tactile and kinesthetic perception. The former is issued from a complex network of mechanoreceptors which are located with varying densities all over our skin. In the most sensitive areas, such as the hands, we can count up to 10000 mechanoreceptors per limb, while in other areas (mainly hairy parts of our body) the density of tactile receptors is much lower. [23]

Four types of mechanoreceptors have been identified, each of which contributes to sensing specific features of a vibrating stimulus applied to the skin. Much research has been devoted in the last decades to identify what these features are, specifically in terms of frequency and amplitude range of perception. For glabrous skin, it is commonly stated that the skin is sensitive to stimuli from 40 to 1000 Hz (with a peak at around 200 Hz), and that amplitude perception can be as low as 1micrometer displacement. [4] These values have been mostly gathered from perceptual studies involving simple, sinusoid-like vibrating stimuli; more recent research though seem to indicate that for more complex signals (i.e. signals with richer spectral content) the upper limit might be higher than 1000 Hz. [3]

Tactile Perception in Art Installations

There are certain types of tactile stimuli which can be conceptualized as similar to visual and aural stimuli. Perhaps the most common experience of this are the vibrations created by high-amplitude low-frequency soundwaves. These sensations tend to be experienced as emanating from the environment, and not as being localized on a specific body part.

Previous projects developed by Salter, including *Just Noticeable Difference* and *Displace 2.0*, present a different approach to this kind of single-signal whole-body stimuli. [18, 19] In these project audio transducers designed for low-frequency signals are attached to platforms. When participants lie or sit on these platforms the vibrations are transferred to their body.

Conceptually, we can create an analog between the difficulty we have determining the directionality of low-frequency audio signals with the difficulty in determining the location of high-amplitude low-frequency vibrations. However, there are key differences. For example, in the platforms described above, the participant's ability to consciously change their seated position causes different parts of their body to come in contact with the platform. The change of sensation generated by this kind of movement enable them to locate the vibration as coming from the platform rather than from the environment. This creates a different kind of immersion from that of an immersive sound- or colour-field. One consequence of this is a limitation to the creative possibilities presented to the artistic creators, in that any sequenced tactile stimuli will be filtered through the unpredictable coupling of the participant to the vibrating platform.

Another way in which tactile sensations can be viewed as analogous to visual and aural sensations is through the concept of sensory translation or sensory substitution. A classic example in this sense is the early work of neuroscientist Paul Bach-y-Rita, who theorized that it could be possible with sufficient training to re-map the visual cortex in the brain of a blind individual to another sensory organ such as the skin. [1] This led to the development in the late 1960s of a prototype of a tactile augmented chair: an array of solenoids attached to the back of the chair would be connected to a videocamera, and display on the back of the subject seated on the chair a *tactile translation* of the image. Scientists involved in the project reported that after some training participants would be capable of recognizing basic shapes through the display.

Of course many artworks incorporate tactile elements which are chosen for their own unique qualities. In Louis-Philippe Demer's "The Blind Robot," for example, a visitor sits in front of a (pseudo-)robotic arm. [5] The arm then reaches out and explores the face of the visitor. While exploring the sense of presence and engaging in a non-verbal dialogue, the main tactile elements of the piece remain the surfaces of the robotic arm as it touches the visitor's skin. Artworks such as this have the benefit of creating systems which can provide specific and highly-detailed tactile stimuli. However, they are limited to only creating the specific stimuli for which they are designed. Conceptually one can imagine them as similar to creating a bell carillon, or any robotic musical instrument whose material properties are fixed.

A different approach to creating a system for tactile stimuli is to have the system itself correspond to the primary characteristic of systems for visual and aural stimuli production. We have the expectation that a stereo speaker system, for example, will be able to create sounds that utilize the full-range of our hearing. This means not only reproducing the perceptible frequency spectrum but also reproducing appropriate amplitude levels as well as spatial location.

A tactile-stimuli system, therefore, should be also able to engage the full range of our tactile senses. In theory this would mean being able to recreate any form of tactile sensation which we might encounter in the real-world. This would require an equal engagement with all of the locations of tactile receptors on our body, with appropriate frequency and amplitude capabilities for each location on the body. In addition, the tactile stimuli created should be able to engage with the different kinds of mechanoreceptors described above.

It should be clear that the creation of such a full-range tactile stimuli generator presents a formidable challenge. The system we designed in no way comes close to fulfilling all of the requirements for such a system. Nonetheless, the design approach we describes one way to attempt to reconcile the requirements of such a full-range tactile stimuli reproduction system with the practical implementation necessary for artistic use.

Immersive Sensory Installations

Ilinx's focus on the combination of vision, sound and touch seeks to go beyond the A/V emphasis of most "immersive" media environments where "surround" is usually defined as an image encircling the visitors. [8] In this sense, with Ilinx's emphasis on exploring perceptual disorientation through cross-modal effects among different sensory modalities beyond vision, the installation participates in a larger critique of visuality that has been introduced by researchers in both new media and in the area of sensory anthropology. [10, 11] Simultaneously, Ilinx builds on and extends several previous projects from Salter and Martinucci that focus on cross-modal sensation, including the above mentioned *JND* (Just Noticeable Difference), and the multi-sensory environment *Displace*. The installation JND, for example, explored how the distinctive modalities of the acoustic and the haptic could be combined within a singular technological and perceptual framework, in particular leading to design choices that emphasized both the separation and combination of both modalities. For example, in designing sound structures that were interesting from both a sonic as well as tactile perspective, the creative team set out to work with material that was not easily representational (i.e., presenting a likeness or reference) and, at the same time, created a strong visual as well as aural sense of space. Tantamount to this was using sound to give the impression of different spaces that would shift from one moment to the next; something particularly important given that any common visual experience of space would essentially be thwarted due to the extreme darkness encountered in the installation environment. This "sense of space" carried over into the creation of specific tactile sensations, particularly the manner in which visitors could feel different tactile patterns on the body and how such spatial patterns could be modulated from clearly perceivable to essentially noise. The focus on immersion not as surround but as something which has tangible embodied presence, that operates on different bodies to produce potential affects is one of Ilinx's major points of departure from both "tangible audio" - based sound as well as immersive media installations emphasizing vision and audition over other sensory modalities.

Tactile Augmented Garments

In terms of the garments developed for Ilinx, several tactile-augmented garments have been produced in the past decades both for research and industrial purposes. We can identify two main categories of devices: performance/entertainment displays and navigational displays.

The first category covers tactile-augmented body suits conceived to be used in performances and art installations, or for enhancing user experience while consuming media such as cinema or tv. Gunther et al. developed a tactile suit intended to be used to compose music for the sense of touch. [9] This *tactile music* would be composed to accompany a regular musical piece and would take advantage of the suit designed for the project. Eleven actuators of different size and power embedded in the suit would be attached to the body of the audience by means of velcro bands. Participants would experience vibration directly correlated to the musical piece composed for the installation. In another implementation, Lemmens et al. design a tactile augmented jacket featuring 64 vibrating actuators to be used for entertainment. [14] The actuators are arranged in 16 independent modules of 4 actuators each and are controlled by a custom software allowing an intuitive design of tactile effects.

In the second category, much industrial research in the field has been driven by potential military applications. Van Erp et al., for example, developed a tactile augmented belt designed to indicate waypoints to impaired users. [21] In this system, a vibrating signal would indicate the direction in which the user has to move.

Piateski and Jones developed a tactile display to be installed on the torso of the user and composed of a 3 by 3 matrix of vibrating actuators. [16] Several patterns of activation of the nine actuators have been tested to convey movement instructions to users. This type of device could be extremely beneficial to visually impaired users, and could take advantage of the haptic channel to receive information about the surrounding environment.

Development of the Ilinx garment

The primary objective at the beginning of the Ilinx project was to more fully engage the haptic channel in an immersive, multi-sensory artistic installation. From the earliest stages our goal was thus to create a garment which would allow for tactile stimuli over the whole of the participants' bodies. In order to create the most immersive and versatile system given the constraints of this project we leveraged contemporary research in haptic perception as well as a modular approach to electronics design.

Leveraging Contemporary Research in Haptic Perception

As previously stated, tactile receptors in the skin are not evenly distributed across the body. This, together with other perceptual effects, limits the number of both spatially and temporally close tactile stimuli that can be perceived as being individual events. For instance, after a prolongated exposure to a tactile stimulus at the same amplitude and frequency, mechanoreceptors eventually stop responding to the stimulation, producing an *adaptation* effect which makes subsequent stimuli go unnoticed. *Masking* effects can also happen when the second stimulus presented too temporally close to the preceding one is not perceived correctly.

The literature on tactile perception states that the average interval between two stimuli is 18ms in order for them to be perceived as separate events, and that the spatial resolution largely depends on the body part being stimulated. [3] Hands and feet remain the most sensitive parts, while torso and forearm for example are much less sensitive. [21]

Other important perceptual effects are so-called *tactile illusions*: for instance, by calibrating the delay between subsequent stimuli one can simulate a motion on the skin of the interested body part. This effect is generally known as *the cutaneous rabbit illusion*. [7]

All these considerations played an important role in our design of the tactile garment and control signals. The number of actuators was limited to 6 per limb, so not to overload the haptic sensory channel with too closely spaced stimuli. The distribution of the actuators was conceived to foster the emergence of tactile illusions such as the cutaneous rabbit: the actuators were disposed on straight lines on the limbs and across the torso to produce illusions of vertical and circular motion on the body of the participants. In our pilot user studies we demonstrated that by varying the temporal delay between actuations and the overlap between each motor actuation, we could progressively move from stimuli perceived as separate events to more continuous ones. This worked particularly well in the vertical direction, while the illusion of a circular motion across the torso could not be consistently produced.

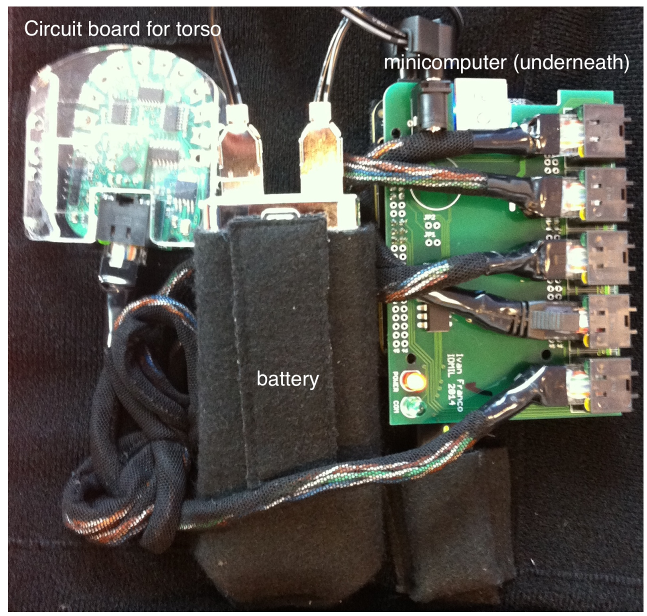

Figure 4: Electronics in the garment. ©Ian Hattwick

Visual Aesthetic

Visual aesthetics also played a strong role in the experience of the wearer and hence, the design of the Ilinx garments. An important consideration from the start was that the garments work as aesthetically pleasing and desirable objects, which could be read, understood, and accepted as a garment as opposed to a technological apparatus. Another consideration was that the garment be unisex so that it could appeal to and be worn by both men and women. The design was inspired by minimalist japanese fashion, such as the clothes of Comme des Garons and Yohji Yamamoto, and executed in muted tones of black grey and dark blue to adhere to the overall installation colour palette. The final design was a deconstructed suit jacket and two separate leg coverings that recall chaps.

Practical considerations

The use of the garment within a public artwork to be presented less than one year after the origination of the project, lead to a formidable set of practical considerations that needed to be taken into account by both designers and engineers within the project. Foremost among these considerations was the durability and stability of the system, concerns with battery life and maintenance, and manufacturing time. A detailed discussion of these issues is contained in forthcoming publications, which address issues including battery management, manufacturing scaling, and useability design.

Wearable Considerations

As demonstrated by previous works employing garments worn by audience members, numerous practical considerations come into play when designing for the body, performance, and multiple-users. [13] As the garments were to be worn by both women and men, sizing had to be adjustable to both sexes and accommodate a wide variability in form and size, including variations in the size of torso and the length and circumference of the arms and legs. As it was important that the garment rest comfortably on the body to maximize the contact points with the vibrotactile actuators, the final design was inspired by athletic and injury braces utilizing velcro or elastics to wrap around the body tightly. The garment parts were reduced to the smallest textile surface needed to house and contain the electronic circuits, which was combined with adjustable velcro straps. A second and equally important consideration was the efficiency and ease of putting on the garment over existing clothes, thus permitting the participants to remain in their clothing, as well as to minimize the need to launder the costumes after each performance or use. Furthermore, it was important that the guides would be able to, with a minimum of assistance from Ilinx staff, quickly put on and remove the garments without damage to the wearables.

Final Implementation

Here we provide a brief description of the construction of the Ilinx garments.

Technical Description

Each garment is embedded with a total of 30 motors divided into 5 groups, located on the four limbs and the torso. Each motor group has its own custom circuit board to generate the signals used to drive the motors. This board also includes a 9 DoF inertial measurement unit which can be used to derive orientation. The five driver boards are then connected via cat6 cable to a central processing-unit, implemented using the BeagleBone Black single-board computer. The BeagleBone Black, battery pack, and driver board for the torso are all contained in a pocket of the front of the garments jacket as seen in figure 4.

As depicted in figure 5, each garment communicates via Wi-Fi to a central computer. This central computer receives sensor data and sends control information for driving the motors.

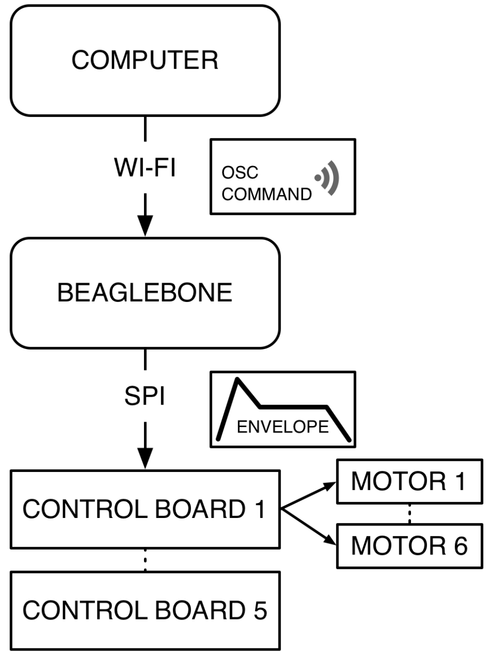

Figure 5: Signal flow showing the central computer communicating with a single garment.

Control Signals

Each motor is driven by a varying PWM signal whose parameters are determined by an amplitude envelope. The job of each motor driver board is simply to translate incoming amplitude envelopes into the appropriate control signals for the motors.

While it is possible for the sequencer on the central computer to generate individual amplitude envelopes it is more efficient as well as conceptually appropriate to produce tactile signals in groupings. These groupings might be intended to create a single perceptual effect, for example controlling sequentially controlling motors laid out along the length of a limb to create a sensation of a vibration moving linearly. When composing an effect in this way it is useful to think in terms of beginning point, end point, overall amplitude, and duration. A sub-algorithm can then be used to generate the individual motors amplitude envelope in real-time.

Wearable construction

In developing the circuitry for Ilinx a number of parameters shaped the final design outcome. The overall weight and flexibility of the garment dictated that we create soft e-textile circuits that could be sewn directly onto the garments, as opposed to relying on rigid and bulky wires. A very low resistance thread was chosen and sewn with a conventional machine to create the circuits. In general, the principal weak spot in e-textiles is often the junction between hard to soft circuit components. These connections can easily come undone and cause electrical or communication drops and breaks. With this weakness in mind a 3D printed casing was designed to contain the actuators so that they could create a robust hub between the hard motors and soft conductive thread. The wires from the actuators were soldered to metal ring terminals which fit on top of circular cutouts in the housing. Conductive thread was then embroidered around the ring terminal which made the electrical connection as well as secured the housing to the garment. This proved to be a very efficient solution as we were able to sew the motors and e-textile circuits together onto the inside surface of the garments, providing a close touch contact between the motors and wearer without the bulk of wires or any issues of lost connection. Finally, after a series of tests, it was determined that a light lining fabric was needed to protect the e-textiles circuits and actuators from getting caught on and pulled by the wearers' garments or accessories while they were dressing.

Initial Presentation of Ilinx

The initial presentation of Ilinx was from September 25-28 at the TodaysArt 2014 festival in The Hague. Over four days more than 300 visitors experienced the installation while wearing the garments. To help meet the challenge of helping that many people don and remove the garments TodaysArt organized shifts of four volunteer guides. Not surprisingly, the interaction of visitor and guide played a key role in the participant's experience.

Figure 6: Visitors being dressed by the volunteer guides. ©Ian Hattwick

Visitor / Guide Interactions

Clearly, the visitors' experiences were highly mediated due to the use of the garments. The most obvious factor was the limited number of visitors able to experience the installation at one time. Six garments were constructed, with the intention that four visitors at a time would visit the installation. In order to create an orderly and planned dressing/undressing period, visitors were asked to make an appointment via on online appointment calendar.

On the first day few appointments were made, as many visitors had yet to find out about the installation and the online appointment system. On subsequent days, however, most of the appointments were quickly filled. Approximately 80% of appointments were kept which allowed for a limited number of stand-by visitors. By the last day the dressing room was a very social environment due to the number of people waiting for their appointment or hoping to fill-in for a missed slot.

The first experience visitors had once they arrived was usually a period of waiting for the previous round of visitors to return from the installation and be undressed. While the volunteer guides were asked not to volunteer information regarding the experience, the visitors still were curious to discuss the reactions of the previous group as well as see the garments being worn before they themselves were dressed.

This injunction for the guides to not volunteer information contrasted with the highly intimate acts of dressing the participants as seen in figure 6. Since the garments contained embedded electronics and consisted of three parts with associated wiring, visitors were asked to not dress or undress themselves. Typical guide/visitor interactions during the dressing phase consisted of visitors asking for information regarding the installation and not receiving any answer, while the guides were adjusting straps and fastening jackets and leggings while asking the visitors how they felt. The final step of the dressing process was the placement of a helmet with a semi-opaque full-face mask which served to limit the visitors vision to detecting areas of light. Once the helmet was in place the guide would take the visitor by the hand and guide them to a spot along a wall, where the visitor would wait until the installation was ready to begin. A picture of participants dressed, positioned along a wall, and ready to enter the installation is shown in figure 7.

When all four visitors were dressed the guides would take their hand and lead them out of the dressing room and a short way along a public hallway to reach the door to the installation space. The installation space itself was pitch-black at the beginning, so once entering the space the visitors were entirely blind. The guides would then lead the participants to chairs located on one end of the installation space, where the visitors would be seated. Each guides would then quietly issue a short set of instructions to the visitor they led in. The instructions indicated where the guide ropes were located and what signal to listen for in order to indicate that it was okay to stand and traverse the installation space.

At the conclusion of the 18 minute event, the visitors would wait for the guides to come and take them by the hand and lead them back to the dressing room. At this point the helmet would be removed and the undressing procedure began.

By requiring this intensive set of dressing/undressing rituals the use of the garments created a specific and highly social environment which bookended the visitors' experiences. In several key ways this augmented the nature of the time spent in the installation proper. The first is that, having seen the previous participants wearing the garments, a visitor would be able to identify themselves as wearing a kind of uniform or costume – a set of clothing which indicates they would be either playing a particular role or would be stepping out of everyday life. The visual combination of the helmet and garment drew many associations from visitors, ranging from martial arts and riot police to science fiction references. This sensation was augmented by the facts that the suits were strapped tightly to their body (in order to facilitate transduction of the vibrations to their body) and that the garments had a certain weight and feel to them due to the embedded electronics and wiring.

A second key element to the visitor's preparations was the level of trust engendered by the guide/visitor relationship. Elements which contributed to this trust were the intimacy of the dressing procedure, the uneven flow of information between guide and visitor, the lack of vision of the participant, the guides leading the visitors by the hand, and the quiet instructions given once the visitors are seated.

Figure 7: Three of the volunteer guides suited up and ready to enter the installation ©Ian Hattwick

Participant Feedback

In order to evaluate the Ilinx experience from a user-centered design perspective, a series of over 100 collective "exit" interviews/conversations were conducted by one of the authors during the installation's premiere in September 2014 in the Hague. Seeking to reflect on how the visitors' sense perception might have been reconfigured during the installation, we utilized techniques arising from the domain of sensory anthropology and sensory ethnography; what anthropologist David Howes has termed "participant sensation." [12] The methodology of participant sensation involves a collective conversation comprised of discussions and recollections and even reflexive analysis of specific sensations and impressions as the visitors are guided through the process of making sense of the novel sensory interrelationships they have just undergone. In this way, many profoundly eloquent testimonies are elicited. Participant sensation (in contrast to the more distanced "participant observation" found in anthropological or sociological ethnographic work) also aligns with Varela and Shear's argument for the necessity of first person methods or what they label 'phenomenal data' to complement third person methods in understanding the workings of consciousness. We engaged in informal yet recorded conversations with the participants in order to capture in language the kinds of almost indescribable bodily affects that might have occurred during the installation experience. [22] As Varela and Shear have argued, "[b]y first person events we mean the lived experience associated with cognitive and mental events". While third-person accounts "concern the descriptive experiences associated with the study of other natural phenomena," first person methods deal with subjective experience that "refers to the level of the user of one's own cognitions, of intentions and doings, in everyday practices."

The interviews with Ilinx participants revealed a number of similar patterns in experience. More than half of the participants interviewed used the word "floating" to depict their experience during the period in which they walked through the space. Moreover, when describing the transition from sitting and experiencing the purely haptic-driven sensations to walking, the majority of the participants indicated a shift in modalities from touch to vision. Although Welch and Warren's notion of modality appropriateness (a hypothesis that claims that when confronted with an intersensory discrepancy, a conflict between different sense modalities, one sense may "bias" another based on the strength of its particular modality) has been recently challenged in the neuroscience literature on cross modal integration, the fact that many participants forgot they were experiencing haptic sensations when in locomotion and instead concentrated on the position and intensity of the light around them, suggests that there may indeed be something specific to the structure of the stimulus in the modality over the modality (vision or touch) itself. [20] More curiously, a number of participants described intense feelings of disorientation, confusion, and, in some cases, vertigo as the result of both having vision blurred and having to walk into the space itself with little sense of spatial visual or acoustic cues. While not statistically rigorous, these exit interviews reveal a strong set of cross modal correlations between modalities that are normally thought to be separate.

Future Work

It was always the intention that the garments designed for Ilinx would form the basis of further work. As always in projects involving the creation of custom technology it is impossible to fully explore their capabilities, subtleties, and implications within the context of a single project. We are therefore fortunate to have several new projects which will utilize the Ilinx garments or build upon them and which will allow us to explore these aspects more fully.

Haptic Fields A direct followup to the current project, "Haptic Fields" focuses on the creation of shared tactile experiences. How can the sense of touch be shared by participants within a space? Additionally, how can we draw upon cultural and anthropological understanding of touch to help develop technology and artwork to further haptics research? In order to scale up from Ilinx's limited number of visitors, we are currently exploring game-based scenarios for both small and large groups which involve the social sharing of and transmission of touch-like sensations among different groups.

Sensory Entanglements The idea of the senses as being cultural constructs leads to the question of how members of different cultural groups can share their sensory experiences. "Sensory Entanglements" brings together First Nations/Indigenous and non-Indigenous artists, scholars, and researchers in a unique research-creation project which seeks to elicit, interpret and experimentally model Indigenous ways of sensing as expressed through art and analyzes the distinctive forms of sociality they support. Among the different sensory contexts to be explored, touch and vibration will feature prominently.

Conclusions

While the incorporation of tactile stimuli in artistic work is increasing, the design of a system able to provide a general-purpose set of tactile stimuli remains a challenge in terms of scalability, somatic considerations and cultural contexts which tend to lend focus to visual aesthetics. The work presented here demonstrates one approach to the design of such a system. We recognize that the garment described herein is capable of only a limited set of tactile signals, partly due to combination of the complexity of the haptic channel as well as the practical demands of the context of Ilinx itself. However, for use in the context of a multi-sensorial art installation we found that the capability of the suit is sufficient to allow for the creation of a wide variety of visual/audible/tactile correlations and hence, a powerful affective experience for the participants.

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