WEARABLE ENVIRONMENTS

ENRICHING USER EXPERIENCE IN AGENT-MEDIATED SPACES

RESEARCH PROPOSAL REPORT

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Abstract

Smart environments and wearable computing are two major branches of ubiquitous computing, providing new opportunities to reconstruct and reform our environment and our relationships with this environment. Generally, smart environments and wearable computing have been posed as opposites and have been combined in most cases to overcome technical hurdles. We aim to investigate what these ubiquitous technologies in concert can afford when we shift our design concerns from the technology to the human experience. We are interested in using this hybrid approach to evoke new relations between humans, machines and environments and reconfigure existing materialities in human–machine assemblages. In what ways can human and machine assemblages be constructed and experienced in agent-mediated wearable environments and in turn how do those assemblages change our horizon for actions? In the process of developing answers to this question, we will particularly focus on emotional and sensual aspects of experiences as parts of our agency. We have determined two main features that can support the co-creation of emotional experience and meaning making: *amplified expressions* and *augmented senses.* This research employs a critical reflective design approach to investigate the varieties of affect empowered by these amplified expressions and augmented senses. The domains of phenomenology and performance will guide the research by providing strategies and accounts for embodied practices of human experience.

More than conversation at the interface, it is creative assemblages … that explore and elaborate the particular dynamic capacities that digital media afford, and the ways that through them humans and machines can perform interesting new effects. Not only do these [artistic] experiments promise innovations in our thinking about machines, but also they open up the equally exciting prospect of alternate conceptualizations of what it means to be human. The person figured here is not a monadic, rational entity but an unfolding, shifting biography of culturally and materially specific experiences, relations and possibilities, inflected by each next encounter – including the most normative and familiar - in uniquely particular ways.[1]

[1] Suchman, L. A. (2006). Human-Machine Reconfigurations: Plans and Situated Actions, Cambridge University Press.

1. Introduction

1.1. Research Context

Computing technologies are increasingly woven into fabric of everyday life. This integration shifts the computing research from the workplace to novel areas of life with its full richness of particularities, ambiguities, relations and experience and consequently brings new agendas for interaction design research, which asks for a reconsideration of its foundations, assumptions and conception of design (Wright et al, 2006). A traditional design goal, productivity with its metrics such as efficiency, effectiveness and accuracy does not provide sufficient support for designing for rich human experience (Boehner et al, 2008; Gaver et al, 2006; Schiphorst, 2008; Zimmerman et al, 2007). There are consequent shifts in culture and society that ask for, and in a way necessitate, new mechanisms for "realizing the world" (Schiphorst, 2008) and new configurations between human, machine and environment (Suchman, 2006).

The technologies preparing the context for change come from ubiquitous computing. Weiser (1991) defined his vision for ubiquitous computing in the following way:

> The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

Ubiquitous computing aims to embed computers into our everyday live in such ways as to render them invisible. Information and computing capabilities becomes available wherever and whenever needed. Smart environments and wearable computing are two major types of ubiquitous computing technologies that are increasingly shape our interactions with people and environment. Smart environments embed sensors and computing capabilities into the environment, whereas wearable computing technologies place them onto the body as wearable garments or portable accessories. Consequently, the way that smart environments and wearable computing interface with people is very different. Since the interface of smart environments has to interact with not only one person but with all the people in that space, they provide a more generic, less personalized and less intrusive interface. However, as the interface of wearable computing has to interact only with the person who wears it, the interface can be more personalized and can interact in more proximate and more intimate ways. For this reason, smart environments and wearable computing have been usually posed as polar opposites (Rhodes et al., 1999). They have typically been combined only if there are technical

requirements like reducing the computational complexity, increasing the effectiveness, or resolving privacy issues (Rhodes et al., 1999; Mann, 1996).

The potentials of a unified interface between wearable computing and smart environment technologies are not yet fully understood within the field of human-computer interaction (HCI) in terms of designing for experience (Rhodes et al, 1999; Schiphorst, 2008). How can these two interfaces be unified in the form of assemblages involving different levels of integration between human and non-human technological agents to expand our potentials for action? How can these two interfaces be unified to use as a tool for critical investigation of agencies? In this research, we define this unification of wearable computing and smart environments as wearable environments.

New media art piece “Mother, Child” by artist Heidi Tikka (2003) is a very useful example for understanding agent assemblages. This interactive video installation blends the agency of a mother with a participant by providing a projected video on the participant’s lap. The mood of the child seems to depend on the situation in the proximity of the projection. If there is a lot of movement, the child becomes restless and starts to cry. The person holding the fabric may gently rock the baby back to sleep. In this artwork, virtual and real elements are blended in such a way that it enables the participant to share a similar agency with the mother by providing the same physical point of view and imitated behaviour of a real baby.

Fig.1. Interactive video installation “Mother, Child” by artist Heidi Tikka(Tikka 2003)

This research will investigate these kinds of human-machine assemblages, how these assemblages are constructed and experienced and in turn will identify the design concerns that will inform the development of technologies. We define agent assemblages as any couplings

between the human and non-human agents that affect the potential of actions of those agents. The importance of these agent assemblages is that they establish different relations, which can open new possibilities towards meaning making as in the case of "Mother, Child" interactive video installation.

This research is aligned with other research studies: critical technical practice (Agre, 1997), embodied interaction (Dourish, 2001), technology as experience (McCarthy and Wright, 2004), and performance practices in interaction design (Jacucci, 2006; Schiphorst, 2008).

The knowledge-rich domains of phenomenology and performance will guide the research by providing strategies and accounts for embodied practices of human experience. These fields allow us to experiment with new forms of couplings between human and non-human agents and to escape from the settled practices, habits and configurations of reality by providing tactics, powered with experiential values. As Jacucci (2006) suggests "reality does not suffice to explore the full extent of the complex and rich world of live human experience". This insufficiency is originated from the preconceptions and habits bounding our actions and experience. Performance studies with their methods and practices provide us useful tools to escape from these restrictions and to stage unique, fictive scenarios and realities that may open up new possibilities for human-machine interactions.

1.2. Research Aim:

The aim of this research is to investigate the potential for combined and shared agency[2] through the mediation afforded by ubiquitous technology, particularly by smart environments and wearable computing. To do this, we will develop a distributed agency framework[3] to study the relation between different degrees of human and machine agency by employing different agent configurations/assemblages under the lens of phenomenology and critical technical design. We will explore the potential where the interfaces of wearable computing technologies and smart environments merge into a hybrid interface involving technological agents and humans

[2] Agency is defined, in its simplest sense, as the capacity for action.
[3] Distributed agency framework involves a symmetrical and dynamic consideration of agency between human and non-human agents. The detailed explanation of this framework will be presented in the Section 3.3.

reconfigured with respect to their physical proximity to each other and different levels of system agency.

The objectives, which will support this aim, are

i. Identification of critical design questions in wearable environments.
ii. Development of a distributed agency framework for investigating the relation between different degrees of human and machine agency
iii. Development of negotiation protocols between human and non-human technological agents to facilitate a creative engagement[4]
iv. Development of prototypes in the form of physical interface agents in concert.
v. Conduct performative case studies to explore the potential of different agent configurations/assemblages with respect to different degrees of system agency and different modes of negotiation.
vi. Identify design concerns and principles that will guide designing for experience in wearable environments.

1.3. Research Questions:

The primary research question that will guide this research is: "In what ways can human and machine assemblages be constructed and experienced in agent-mediated environments and in turn how do those assemblages change our horizon for actions?"
The secondary research questions are as follows:

i. How do different physical agent configurations/assemblages with different levels of system agency affect human agency?
ii. How can the negotiation process between agents (human and system) be supported to extend our expressive capabilities[5]?

[4] Creative engagement is an interaction mode suggested by Bilda (2008) in which user can end up with creative outcomes or can reflect in action. This mode will be further discussed in Section 3.2.
[5] Extension of expressive capabilities might be realised in two ways: either through the discovery of new bodily gestures or through the amplification of existing gestures' effects.

iii. How can interdisciplinary collaborations between designer, programmer and performer provide new conceptual insights into the design and development of agent-mediated environments?

1.4. Contributions and Significance:

1.4.1. Why is this research significant?

This research is significant because it brings a new perspective for the development of ubiquitous computing technologies, smart environments and wearable computing. This new perspective aims to couple these technologies not to resolve technical insufficiencies but to evoke new relations focusing on human experience. This will open a new area for inquiry and experimentation for the agencies of human and non-human entities. This experimentation can challenge the current understanding of agencies and can support the creation of new relations.

Previous research studies that are relevant to this research can be grouped under two categories: Firstly, there are research studies addressing the importance of human experience in technology design (Forlizzi et al 2004; McCarthy et al 2004) and secondly, the research studies that investigates the various roles of performance studies in interaction design process (Iacucci, 2002; Schiphorst, 2008; Xin Wei, 2002). This research shares similar concerns with these previous research studies, but it focuses particularly on the ways to extend expressive agency by developing a distributed agency framework that facilitates communication between agents and allows them to share their expressions.

1.4.2. How will the research outcomes contribute to the knowledge base of the field?

The outcomes of this research will be a distributed agency framework, rigorously documented design and evaluation processes of performative case studies and critical reflection on various agent assemblages and on conception of agencies.

The agent framework will extend ubiquitous computing interaction paradigms by unifying the interfaces of smart environments and wearable computing by facilitating different levels of integration through different physical configurations between the agents. Critical reflective design approach with a phenomenological account will enable us to challenge the basic

assumptions and foundations of the field and enable us to focus on first person experiences of relations and technologies.

The documentation of design and evaluation processes will provide knowledge about performative ways of designing for experience, which will be a significant part of that theory of designing for experience being developed.

The critical reflection on various agent assemblages will inform us about the potential and experience of those assemblages and it will contribute the theoretical discourse of agency by a practice-led critical study of agencies.

1.4.3. What are the innovations of the research?

i. **Conceptual innovations:** This research follows a similar approach to previous research that uses first person and third person observational strategies for evaluating human experience. In addition, this research allows the first person and third person perspectives to be shared during the exploration and design phases. This leads us to an extended notion of agency.

ii. **Methodological innovations**: This research develops a method for experimentation and evaluation that adopts elements of critical design, ludic design, critical technical design and performance to articulate and evaluate agent assemblages/configurations.

iii. **Technological Innovations**: This research will combine technologies from smart environments, wearable computing and multi-agent systems into a hybrid interface involving various degrees of physical integrations between the agents.

2. Background

"It would be possible to describe everything scientifically
but it would make no sense; it would be description
without meaning, as if you described a Beethoven
Symphony as a variation of wave pressure."
Albert Einstein[1]

In this section, firstly, the need for a change in our idea for design will be discussed and various approaches different from the design-as-engineering perspective will be presented. Then, the phenomenological views to interaction design with the concept of embodiment will be introduced. After explaining different notions on agency, the performance-based perspectives to interaction design will be mentioned by giving a few examples. At the end of the section, a summary of these studies will be presented and the way they inform our research study will be explained.

2.1. User Experience and Idea of Design

Computers are no longer just tools for work but they are the objects we live with and are increasingly re-shaping our lives and environment (McCarthy, 2004). When computers went out of workplaces, they crossed not only physical but also social and cultural boundaries, and designing and building these objects and systems require "analysing and incorporating the stories, meanings, and social networks that these devices engage" (Sengers, 2004). The previous design goals guiding technology development should be extended to cover a different set of questions to address these concerns (Sengers, 2004). Why do we want a product or prototype to work in a particular way in the first place? Why are specific design decisions made? What alternatives should we consider? How should our design change on the basis of these insights? There are also questions of power, control and accountability (Galloway, 2003).

[1] Clark, R.W., Albert Einstein in *Einstein: The Life and Times*, World Publishing Company, 1971, p. 192.

In this research, we will deal with these types of questions that situate technology design in its personal, social and cultural context. We will focus on the theme of personal experience of these technologies and the way design choices shape these experiences and resulting implications and in turn how can these inform us to design for the development of these technologies. This takes us to the idea of designing for experience.

Wright et al (2003) have highlighted the importance of developing a conceptual framework to enable designing for experience:

> There is … an uneasy silence as to what actually constitutes experience. Questions such as how to set boundaries distinguishing a specific user experience from a general flow of experience, how to account for subjectivity, and whether it is possible to design for experience, have remained conspicuously unanswered. In short, despite a growing acceptance of the need to focus on experience the concept of user experience is not well developed conceptually. Without conceptual development, there is a danger that user experience and related concepts such as trust, loyalty, identity, and engagement will not be fully realized in studies of people and technology.

They proposed a framework based on the philosophical work of John Dewey (1934) and Mikhail Bakhtin (1993) not as a tool for analysing the experience but as a set of conceptual tools or a language for thinking and talking about it. It is intended to demonstrate the sensitivities for some essential characteristics of experience. The framework identifies some main threads of experience coming from a variety of perspectives ranging across cognitive, behavioural, emotional and socio-cultural dimensions.

The concept of Embodiment and Embodied Interaction gains significance within the field of HCI (Dourish, 2001). This is partly related with the interest towards to design for user experience and tendency to associate the concept of embodiment with the experience. Schiphorst (2008) states that growing recognition and value of embodiment experience could be evidenced in part by a remarkable increase in publications focusing on various aspects of experience and embodied interaction.

In the context for design activity, Wright et al (2006) claims that our idea of design needs to change according to changing conceptualization of user in terms of experiential values. They pointed out that design-as-engineering perspective is successful particularly if the domain of application is well regulated, relatively closed and the user's goal and role in the system the can be well defined and adequately captured. However, this is not the case where users are not the traditional users of HCI as task do-ers, environments are not only workplaces and computers are not only tools in traditional sense. The richness of the concept of experience will not be fully covered and reduced to cosmetic properties of interface and issues of control and prediction. Although they suggest a design-as-craft perspective, which considers design as being necessarily an engagement with particularities with an emphasis on the process of making sense of the situation reflectively, they concluded that none of the perspectives alone is sufficient and a radically interdisciplinary dialogue crossing sciences and arts is required. Finally, they maintain that a critical reflective practice, in which practitioners' continually question assumptions and ways of interpreting, is well suited when arts and science meet in interdisciplinary dialogue.

Recent research studies (Boehner et al., 2008; McCarthy and Wright 2004; Sengers et al. 2008) emphasize the limits of the codification approach when dealing with user experience. The drawback of trying to codify, generalize, and formally model the aesthetic experience for technology is that it may miss the precisely the phenomenon that was originally interest (Boehner et al. 2008).

Boehner et al. (2008) follows an approach, which "shifts primary focus from the system's internal representations to user's interpretations and experiences around system". This shift in focus results in subsequent shifts in design and evaluation approaches. Boehner et al. explains that:

> Our goal for design … shifts from systems that accurately acquire, represent, and reason about human activity to ones that respond evocatively to human activity, providing new opportunities for users to have, interpret, and reflect on their own experiences. Our goal in evaluating these systems shifts from measuring how accurately systems can

> track and communicate human activity to how design choices support certain kinds of interpretations and experiences in real-world contexts.

Their considerations for designing "culturally embedded" systems are the activities, experiences and interaction that arise around the system, rather than on what the system can do by itself. The systems designed by them do not represent user but respond to user activity and facilitates co-constructed experiences. They do not want to propose guidelines or specific formulas for repetition but offer strategies and their implications as a way of sketching out a space to explore by narrating how it was that the system came to be known or lived as a success or failure. To judge the success of the system they look at metrics such as levels of engagement, enjoyment of use, integration with everyday experiences, the variability of use or capacity for re-appropriation rather than whether or not a user "got it right" or "performed more efficiently". At the end, they state that their aim is to "intimately couple" technical codification process with the ineffable complexity of human experience that enriches those codes and makes them not just right, but meaningful (Boehner et al., 2008).

Parallel to this suggestion, Suchman (2006) claims, "that object of design must shift. Rather than fixed objects prescribe their use, artefact-particularly computationally based devices – comprise a medium or starting place to elaborate in use".

Sengers et al (2006), considering the influences from arts and humanities and new domestic domains of design, assert that multiple and potentially competing interpretations for the systems can fruitfully co-exist. As a result, since the HCI does not have to decide upon and support specific, correct interpretation of system, the aim becomes finding to ways to incorporate and balance multiple, perhaps conflicting interpretations and processes of interpretation in design and evaluation. She exemplifies some typical questions that supports open interpretations:

> … not "did the preferred interpretation take hold with users?" but "How many different interpretations does a particular 'blank canvas' generate, and why?" or "Do users feel both stimulated and empowered to develop their own interpretation of an alien presence system?

Sengers et al (2006) underline that their methods are not intended to replace the single interpretation systems or systems that are completely open to interpretation but intended to "allow the rhythms of constraint and openness in interpretation to become part of the design language available to us in HCI".

Gaver et al (2004) follow a similar approach by applying cultural probes for designing for pleasure. Their approach values uncertainty, play, exploration, and subjective interpretation as ways of dealing with the limits of knowledge. Their aim is to gain inspiring design ideas for technologies that could enrich people's lives in new and pleasurable ways. They propose a reverse approach to the normative scientific by advocating particularities, ambiguity and subjectivity. Gaver et al maintain that:

> Asking unambiguous questions tends to give you what you already know, at least to the extent of reifying the ontology behind the questions. Posing open or absurd tasks, in contrast, ensures that the results will be surprising.
> Summarizing returns tends to produce an "average" picture that may not reflect any individual well, and that filters out the unusual items that can be most inspiring.
> Seeking for justifiable accounts of Probe returns constrains the imaginative engagement and story-telling which can be most useful for design

In a recent study, Gaver et al. (2009) described an anatomy of failure case for one of their probe studies. This example was particularly important for critical design research, because It clearly explained how open-ended systems and strategies for their 'polyphonic' assessment need not be incompatible with making definitive assessments of success or failure that can help shape future design work. This explanation was particularly important as a response to the some counter attacks labelling this approach with anything goes mentality. They evaluated the success of their system according to four themes: engagement, reference, accommodation, and surprise and insight. Then they examined the reasons for different levels and pointed out problems related with redundancy, system's lack of providing alternative forms of engagement and finally deviation of focus from design as research to design for research. According to them, design for research consists of design activities pursued primarily in service of a theoretical concern whereas design as research embraces design activities that balance

multiple concerns to produce compelling experiences followed by conceptual pay offs. Design as research tries to shift current perceptions of technology functionally, aesthetically, culturally and even politically.

2.2. Embodiment, Embodied Interaction and Phenomenology

The body is our general medium for having a world.[1]

According to Dourish (2001), Embodiment is "the property of our engagement with the world that allows us to make it meaningful" and Embodied interaction is "the creation, manipulation and sharing of meaning through engaged interaction with artefacts".

Dourish uses a phenomenological perspective to illuminate the foundational underpinnings of embodied interaction. He explains in phenomenological terms how meaning-making processes are connected with our action and existence, how meaning arises from the way we encounter the world and how different meanings are reflected from the world we act in.

He identifies three aspects of meaning: ontology, inter-subjectivity and intentionality. All of these three aspects emphasize the personal, dynamic, perceptional and lived properties of meaning-making processes. Inter-subjectivity is about how meaning can be shared. For successful achievement of communication of meaning in interactive systems, it is required to have a common ground to share our intentions. Intentionality refers to the directedness; our actions are directed towards something. There are two sorts of intentionality: original intentionality (action arises from intentionality) and derived intentionality (intentionality arises from action). Dourish claims that the latter is more significant. Ontology (philosophy of existence, structures and relations) is not independent from the interaction and there is no pre-existed and fixed ontology and it is "something that arises out of participative practice" (Dourish, 2001). This claim is aligned with our consideration of the network of agents that configures ontologies.

[1] Merleau-Ponty, M. (1962). Phenomenology of perception (C. Smith, Trans.). London: Routledge.

Embodiment is a major concern within phenomenology, which is a philosophical attempt to escape from Cartesian body and mind dualism and deals with the subjective human experience. Husserl, Heidegger and Merlau-Ponty are major philosophers of phenomenology. The body and the notion of embodiment is the most central in Merlau-Ponty's phenomenology (Dourish, 2001). Svaanes (1999) points out eight aspects of his work that are directly relevant to HCI:

- **Perception requires action**.
  Without action there can be no experience of anything "external" to the subject
- **Perception is governed by a "pre-objective" intentionality**.
  Most of the interactions are governed by inborn intentionality towards the world.
- **Perception is embodied**.
  We perceive the world with and through our active bodies.
- **Perception is an acquired skill**.
  Perception is to a large extent an acquired bodily skill that is shaped by all our interactions with the world.
- **The perceptual field**.
  Our experiences have shaped our way of being in the world. This creates what Merleau-Ponty denotes the perceptual field.
- **Tool use**
  When we learn to use a tool, it becomes integrated into our body both as potential for action and as medium for perception.
- **Bodily space**
  When we act in the world, our body has a dual nature. On the one hand, we can see it as an object among other objects in the "external" world. On the other hand, it exists to us as our experiencing/living body. As a living body, we move within a space given by the structure and limitations of our own body and our bodily space.
- **Abstract vs. concrete movement**
  A movement changes nature from "concrete" to "abstract" when it is done consciously.

Svanes summarizes the Merleau-Ponty's notion of perception that is totally different from the naive idea of perception as stimuli reception:

> Perception is a process where an active body enters into a "communion" with its surroundings. Perception is a continuous interaction involving the subject's intentions, expectations, and physical actions.

Svanes further claims that by the application of Merleau-Ponty's philosophy to human-computer interaction, we develop an understanding of interaction as perception and we resolve the Tool/Media dichotomy. He states that since perception is an active process, we no longer consider it as passive reception of information through medium and since action is an expression of our-being-in-the-world, we do not treat it as a purely "bodily" activity anymore.

These phenomenological views define our phenomenological lens that will be used as a filter and guide for our research. This lens allows us to focus on human without dividing it into body and mind, allow us to situate that human and his/her experience in a dynamic network of relations, and allow us develop an embodied understanding and awareness of perception and interaction when designing and evaluating interactive systems.

2.3. Agency and Artifacts

Agency

Suchman (2006) defines agency in its simplest sense as the capacity for action. She points out the argument of Gell (1998) on situated characteristic of intentionality of human agency:

> … intentionality needs to be understood not as an attitude of mind located within the individual, but as a field of socially and materially mediated possibilities within which persons act.

Suchman also underlines Barad's (2003) concept of "agential realism", through which realities are constructed out of specific apparatuses of sociomaterial "intra-actions".

> While the construct of interaction presupposes two entities, given in advance, that come together and engage in some kind of exchange, intra-action underscores the sense in which subjects and objects emerge through their encounters with each other.

This suggests a definition of agency as not an attribute belonging to either humans or other entities but as Barad suggests "the ongoing reconfigurations of the world". Similarly, Callon (1999) defines the network in the context of Actor-network Theory as

"not a network connecting entities which are already there, but a network which configures ontologies. The agents, their dimensions, and what they are and do, all depend on the morphology of the relations in which they are involved".

Finally, Suchman (2006) proposes an alternative approach against the understanding of autonomous agency of twentieth century technoscience that:

> The alternative perspective … takes persons and machines as contingently stabilized through particular, more and less durable arrangements, whose reiteration and/or reconfiguration is the cultural and political project of design in which we are all continuously implicated. Responsibility on this view is met neither through control nor abdication, but in ongoing practical, critical, and generative acts of sociomaterial engagement. The point in the end is not to assign agency either to persons or to things, but to identify the materialization of subjects, objects and the relations between them as an effect, more and less durable and contestable, of ongoing sociomaterial practices.

Kaptelinin et al. (2006) argue that Actor-network Theory's consideration of the agency of things is right in terms of demonstration of insufficiency of the traditional account of "only people who are doing the acting". They point out Pickering's (1993) concept of symmetrical agency based on a dialectical notion of back and forth between the human and material worlds. According to Pickering, material and human agency were "constitutively enmeshed in practice by means of a dialectic of resistance and accommodation". Kaptelinin et al. states that Pickering's formulation of material agency is intelligible only with respect to human practice as expressed in Pickering's original statements: "I argue that material agency is … emergent in relation to practice"; "material agency is sucked into the human realm"; and "the resistances that are central … always situated within a space of human purposes, goals and plans".

Kaptelinin et al. define agency as "the ability and need to act" where acting stands for "producing an effect according to an intention". They proposed a framework breaking down the concept of agency into several subtypes and demonstrating how different kinds of agents may exhibit similar or different agencies under varying circumstances. Three types of agencies and five types of agents comprising the framework are depicted in Table 1.

Agencies	Agents	Things (natural)	Things (cultural)	Nonhuman living beings (natural)	Nonhuman livings beings (cultural)	Human beings	Social entities
	Examples	tsunamis, Northern lights, vernal pools, Martian rocks	speed bumps, sewing machines, teapots, adzes	grizzly bears, California poppies, truffles, protozoa	house cats, Dolly the sheep, GMO corn, Bourbon roses	Spinuzzi's traffic engineers, Miettinen's scientists, ANT's princes	World Trade Organization, ISO, Doctors without Borders, United Nations
Conditional agency	Produce effects	+	+	+	+	+	+
Need-based agency	Act according to own biological needs	–	–	+	+	+	–
	Act according to own cultural needs	–	–	–	–	+	+
Delegated agency	Realize intentions of (other) human beings	–	+	–	+	+	+

Table 1. Forms of Agency (Kaptelinin et al, 2006)

By means of this agency framework, which extends the notion of agency beyond human subject, the asymmetry of the subject and the object postulated by Activity Theory becomes more sensitive to the agency of non-human entities, and supports richer representations of real-life settings.

For our research study, we aim to contribute theoretical discourse of the notion of agency by a practice-led research challenging the assumptions and claims of aforementioned different approaches on agency. In this manner, we believe that Actor-Network Theory's symmetric view of agency will provide a flexible base for the experimentation.

Artefacts

Wartofsky (1979) identifies three types of artefacts, primary, secondary and tertiary. While primary artefacts are used directly in productive act, secondary artefacts are representations used in preserving and transmitting the skills and modes of acting through which productive practice is realized. Secondary artefacts works like a manual for how to use primary artefacts; they mediate and support the development of tool-related competencies. Tertiary artefacts are abstracted from their direct representational function and they emphasize creativity. Bertelsen (2006) emphasizes the significance of tertiary artefacts that can change productive practices:

> Tertiary artefacts have origins in the productive practice but do not depend on it directly. They constitute an autonomous zone of free creation of visions that transcends the existing modes of perception and action in societal practice. Thus, tertiary artifacts reshape human perception, thereby influencing and changing productive practices. The representations … with the concept of tertiary artifacts are those produced in liberal arts, and the main point of Wartofsky's argument is the relation between art and societal praxis in general.

Further, Bertelsen proposes that the dialectics between transparency and reflectivity in tools and in art are crucial for the development of third generation HCI. These correspond to two modes of engagement as transparent mode that is a desired property of primary artefacts and reflective mode that is a desired property of tertiary artefacts. Bertelsen suggests "focusing on elements of tertiary artifactness integrated with the tool interface, allowing poetic openings into contingency and imagination, and supporting the development of transparent interaction without prescribing a specific curriculum".

The feature of "tertiary artifactness" to be integrated with the tool interface is quite similar with the notion of "accounts" (Dourish, 1998); computational representations which systems continuously offer of their own behaviour and activity, as a resource for improvised and contextualized action. They both intend to integrate a reflective sensitivity into the tool perspective in design.

The distinction of three types of artefacts is useful in term of clarifying their differences, relations and links to creative and productive practices. In the context of this research, tertiary artefacts and reflective mode of engagement are desirable as they allow "poetic openings into contingency and imagination" (Bertelsen, 2006) for mediating the interactions among entities.

2.4. Performance Perspective to Interaction Design

In this section, I will introduce the research and artistic studies of Jacucci (2002), Schiphorst (2008), Wei (2002), and Chalayan (2001) as source of inspiration and as a base for performance perspective for interaction design. Jacucci investigates the role of

performance in interaction design and proposes a manifesto for performative development of ubiquitous media. Schiphorst bridges the experiential bodily techniques and methodologies from the fields of performance and somatics to the interaction design and demonstrates the usage o techniques in different phases of design and development cycle of interactive systems in the form of performance installations. Xin Wei explores the interaction, gesture and agency through performative phenomenological experiments as a tool for philosophical inquiry. Finally, Chalayan is designing innovative clothes equipped with machine artefacts allowing alternative relations with other people and environment and varieties in use.

Jacucci (2002) explores the role of performance practices and in which ways they can support design activity. First, they can support exploring and inventing ideas, second it provides methods and techniques to represent and communicate a scenario, and finally it enables us to test and experiment with all the entities. Jacucci suggests that the view from anthropology and performance art with a focus on understanding the experience and performance of culture provides a useful base in the context of interaction design.

From the studies of Turner (1987), Barba (1991) and Acconci (1981), Jacucci (2005) point out the traits that can be used to formulate a performance perspective to interaction design privileging novel aspects. He summarized these traits in six groups:

- Accomplishment and Intervention. Performance is always something accomplished and an intervention in the world.
- Event and processual character. Performances have generally a beginning, a sequence of developing phases and an end.
- Expression and Experience. Experience structures expression and expression structure experience in a coherent system of interaction and interpretation of cognition (thought), affect (feeling) and will (volition).
- Space, artefacts and interaction. Performance can be linked in many ways to expression, through bodily movements, artefacts or architectures.
- Perception, simultaneousness of doing and undergoing. There is a structural relationship between doing and undergoing which leads to perception and to new insights.
- Energy and consciousness. There are differences between daily activities and extra-daily activities in terms of energy, skill and consciousness. Barba (1991) points out that for the techniques of daily activities, we try to obtain maximum

benefit with the minimum effort, whereas extra daily techniques are based on "wasting the energy".

I found these traits very useful since they provide relevant concerns for designing for bodily experience and for investigation and experimentation of new relations among entities in physical space equipped with physical machine mediators. Most of these traits are also aligned with Merlau-Ponty's phenomenological views on perception like embodiment of perception, action-based perception, perceptual field and bodily space. I only have disagreement on the usefulness of the trait of having processual characteristic. I found this item too much emphasizing sequential creation of the meaning with a peak at the end.

Finally, Jacucci (2005) provide a table, Table 2, demonstrating the radical shift in values and processes for designing for physical interfaces brought by performance-based perspective. Here, some important shifts are from tasks to events, from recognition to perception, from usability to expression, from personalization to configuration and finally from sensing systems to sensing humans. We see that this shift in values and processes puts human and his/her perception and experience into the centre. Thus, the performance-based methods with these properties are well suited for designing for experience.

General human-computer interaction tenets	Performance applied to physical interfaces
Task, timeless, universal, general	Event, contingent, ephemeral, unique
Recognition, affordance	Perception, sense experience
Usability, accountability	Expression
Behaviour	Individual's expressivity
Supporting the creation of a product	Supporting the staging of a process
Users, consumers, administrators	Participants, directors, performers
Personalising, computer artefact's view	Configuring, actor's view
Sensing system	Sensing humans
Measuring, simulating space	Configuring, performing space
Tracking movements, objects	Amplifying movements, augmenting objects
Recognising, sensing situations	Staging, configuring situations
Eliminating secondary tasks	Amplifying action and communication

Table 2. The contribution of the performance perspective in Interaction Design Program (Jacucci, 2005)

Schiphorst (2008) explores human experience and its inseparability from the material processes of technology and to transfer the knowledge from the field of Somatics to HCI. More specifically she tries to demonstrate how embodied values of Somatics can be utilized in the different phases of design and evaluation processes of HCI and how research through art can be applied to explore, design, document and evaluate the research intentions.

She first analysed the theories and practices of embodied experience between HCI and Somatics, which lead to identification of a set of design strategies that were examined through a series of interactive art installations with a reflective and critical stance. Finally, case studies provided evidence in the form of rigorously documented design processes depicting these strategies. Each of the three installations corresponds to a different phase in the design cycle. These phases start with experience design enquiry, followed by concept realization and technological realization and end with evaluation of quality of experience.

Schiphorst focuses on four main values of first person embodied practices: the value of self, the value of attention, the value of experience and the value of inter-connectedness as guiding criteria for design and evaluation

Schiphorst's study is a very sound demonstration of designing for experience by applying methods from the fields of somatics and performance in different stages of design activity. We will take her research approach as a base for designing for experience by applying methods from the performance studies and by linking first and third person perspectives in design and evaluation. In addition, we will further investigate the potential of combining first and third person perspectives within the performative case studies, i.e. in actual meaning creation process.

Wei defines his studies as "phenomenological experiments about interaction and response, agency and intention" (2002). In TGarden, a responsive space, actors-spectators improvise gestures with specially designed costumes equipped with sensors (Wei, 2007). This responsive space supports the improvised gestures by producing synthesized media elements like light projections and sound. As Wei (2002) describes TGarden:

> [Its] software tracks gesture rather than recognizes gesture, because at no place in the software is there a 'model' that codes the gesture ... The software does not infer what the player means by her gesture, it merely tracks the gesture and continuously synthesizes responses. So what we have done is to set aside entirely the problem of inferring human intent from behaviour, or more generally from observables. Yet by providing and even thickening the sensuous response, we make fertile the substrate for agency. This approach remains agnostic as to whether movements are intentional; the responsive system simply does not need to know.

He points out that the boundary between actor and spectator becomes blurry, so "anybody may adopt the disposition of an actor as an agent of change in the event, or equally a spectator as a witness of the event" (Wei, 2007). He explains his ultimate goal in the following statement:

> I propose to bracket the boundaries of the human in order to understand not so

> much the what but the how of the human experience: I would ask not "What is a human?" but, to borrow Anne Weinstone's phrase, "How to human?" One conventional limit of the human is the fleshy body, so let us bracket it.

The ways he follows to bracket the limits, are performance research and phenomenological experiments. He advocates that they provide suitable ground to experiment and force the boundaries.

What we need is to shift our emphasis from spaces of representation to space of experience, what we need is to shift our emphasis from "taxonomy, and schemas and classifications or standards and protocols … to the dynamics of processes that stir, up, shape, and unshape the material patterns that constitute the life world" (Wei, 2007) in favour of improvised gestures and relations in responsive media saturated mixed reality spaces.

Figure 2. Players in TGarden (Wei, 2003)

Wei's study is a complicated philosophical inquiry of being a human. As Suchman (2006) points out that projects like TGarden, the specific materialities of computing are under investigation and re-configuration while rejecting the conventional conceptualization named as smart machine. The human experience focused performative experiments, as a philosophical inquiry in TGarden is a good example in terms of demonstrating exploration of varieties of agent relations in agent mediated environments. The TGarden's software does not have any human-like "intelligence" embedded into the code; the rational behind this is to radically investigate the alternative materialities of computing. This is a good point in terms of challenging the widely accepted agency of

computers that is obliged to mimic human agency. However, it is not clear how their use of quasi-physics is different from a simple reactive system. Similar to TGarden, our study will also investigate the notion of agency in agent mediated environments, but it will specifically address two ubiquitous technologies, smart environments and wearable computing and focus on not such a broad inquiry of how to human but on particular forms of agent assemblages allowing agencies to be shared and blended.

Hussein Chalayan (2001) is a regarded fashion designer producing innovative garments that force the limits of wearable things. His designs facilitate new relations between human body and environment and allow varieties in use. One of his famous collections included chairs and tables that became garments, see Figure 3. For other designs, he experimented LEDs, lasers, motors and some other alternative equipment to extend the phenomenal field and bodily skills[1] of the wearer and possibly the observer. His works are important in the sense that they challenge the traditional and established conceptions of artefacts, humans, environment and their roles and relations. He plays with these conceptions and reconfigures the relations, which can evoke new experiences and extend our horizon for actions.

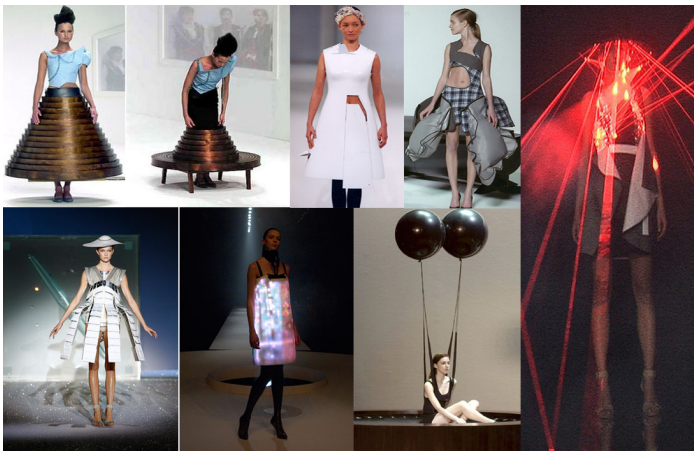

Figure 3. Innovative wearable designs by Hussein Chalayan (2001)

[1] These terms were proposed by Merlau-Ponty in his book Phenomenology of Perception, 1967

2.6. Discussion

The previous research pointed out the need for a change or extended understanding of idea of design. Design-as-engineering perspective is not sufficient alone when designing for technologies that we not only work but also live with them. We need to analyse and consider the personal experience and social context with a critical stance.

There are many efforts for developing a framework for designing for human experience; they do not work as formal guidelines or models but accounts and sensitivities that should be considered in design activities. Although, the applications of these frameworks are largely interpretative for the practitioners, it may not be an undesirable thing. Since the concept we design for is the experience, these flexible interpretations might better accommodate the irreducible and rich nature of human experience.

There is also another body of work in the literature critically dealing with the role of technology and varieties of technological engagements in everyday life. These research studies are significant because they focus on the design choices and resulting implications on people's lives and society. They challenge the specific materialities of technology and investigate alternative ways of relating with these technologies. In order to do this, they focus on human experience, and contextualize technology in culture through a critical reflective approach.

Another concept that is under investigation by different research fields is agency. Agency is a key concept in Artificial Intelligence (AI) field. Infrastructures for multi-agent systems, agent communication and agent network topologies are some of the widely investigated aspects. What has not been so much investigated in AI field is the notion of agency itself. It is accepted almost without hesitation that the ultimate goal for machine agency is to be like human agency. On the other side, there is a large body of philosophical literature on the notion of agency and an ongoing discussion about the concept.

We aim to have critical design approach for investigating the varieties of agencies emerged from human machine reconfigurations afforded by ubiquitous technologies.
What we do not know is that what these ubiquitous technologies in concert can afford when we shift our design concerns from technical and service based aspects to human experience centred aspects that can evoke new relations and reconfigure existing materialities of human machine assemblages.

In which ways are human and machine assemblages constructed and experienced in agent-mediated wearable environments and in turn how do those assemblages change our horizon for actions?

3. Approach and Methodology

This research is situated across the domains of Ubiquitous Computing, Interaction Design and Performance Studies that will be filtered by a phenomenological lens. A critical reflective design approach will be developed.

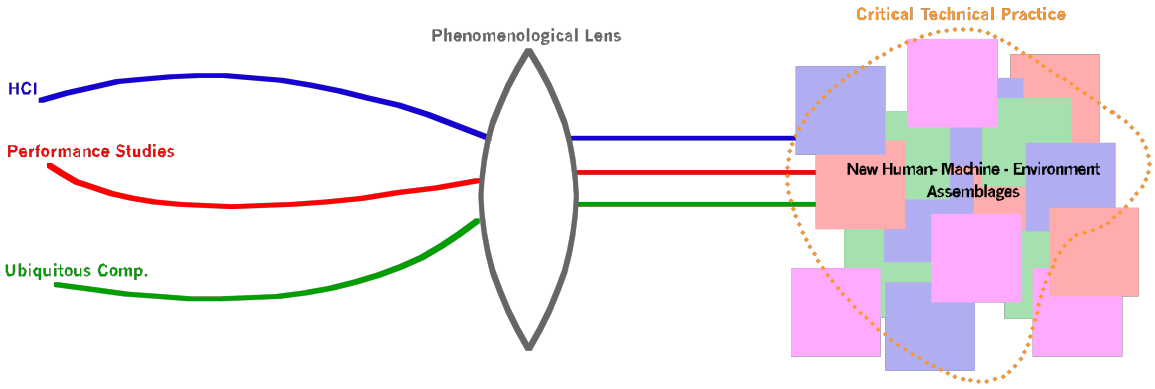

Fig.4 Research Building Blocks

The ubiquitous computing domain is a large field of research comprised of many sub-fields. Of them, wearable computing and smart environments are two that are most relevant to our research. While wearable computing augments the body with computing, smart environments prefer to embed them into the environment. Our research study lies at the intersection point of these two fields and will try to exploit the neglected potential of unity of these two technologies.

The interaction design field and more specifically the HCI subfield promote the importance of human experience in design. The richness of the concept of experience cannot be fully covered by a design-as-engineering perspective and this brought a need for a change in our idea of design (Wright et al, 2006). Parallel to this need, there has been various attempts to provide a theoretical foundation for embodied interaction (Dourish, 2001), a framework for user experience (Forlizzi & Battarbee, 2004) and a reconsideration of technology as experience (McCarthy & Wright, 2004). Our approach for design will comply with this recent turn to experience and will follow a practice-led critical reflective design approach.

Resonant with the turn to experience in design, methods and techniques of performance studies have been increasingly integrated into design activities. Jakucci (2002) pointed out that performance practices can contribute to the design activities in three ways. First, they can support exploring and inventing ideas, second they provide methods and techniques to represent and communicate a scenario, and finally they enable us to test and experiment with all the entities involved in performance. Our research study will utilize methods and techniques from performance studies to explore and invent ideas and relations. Performance studies with their many strategies for representing, staging and acting will allow us to create a fictive reality in which we are no longer bounded with the established and conventional relations and connections between entities or agents.

By means of a phenomenological lens, we will be able to focus on first person human experience and experiential values (e.g. affect, engagement, self, awareness and inter-connectedness) that will guide our design and evaluation strategies. The phenomenological lens will allow us to escape from technical rationality and allow us to attend to the particularities and uniqueness that can be very valuable and insightful. Our research will benefit from first person experience and observations that will be linked with third person perspective to gain knowledge by sharing observational strategies and techniques. Schiphorst (2008) references Varela and Shear (1999) advocating that there is a need to link crucial subjective first person methodologies to third person studies and this can be done by introducing second person position. She defines her research as a bridge between first and third person perspective and thus as a second person perspective. Schiphorst states that:

> While third-person methodologies use observation to gain knowledge about the world, first-person methodologies use observation to gain knowledge about the self. Based in self-observation, they use the direction of attention or awareness to re-educate perception. … Other disciplines that use first-person methods refer to them in a number of ways. Within phenomenology these techniques are referred to as epoche, reduction-suspension or phenomenological reduction, within psychology as introspection or reflection and within contemplative traditions they are referred to as mindfulness.

Aligned with first person observational and experiential approach and staging and acting practices from performance studies, this research will follow a critical reflective design methodology (Sengers, 2005) and it locates its approach between Critical Design (Dunne and Ruby, 2001), Ludic Design (Gaver, 2004) and Critical Technical Practice (Agre, 1997).

Critical design is an approached proposed by Dunne and Ruby (2001). The aim of critical design is to involve both users and designers in a process of exploring new ways of looking at the world and to stimulate thinking about the role designed objects can play in this process (Sengers, 2005).

Based on the notion of designing for homo ludens: people as playful creatures, Ludic Design provide an alternative way of looking at playful and ludic activities not merely as a matter of entertainment or waste of time but as "mechanism for developing new values and goals for learning things and for achieving new understandings" (Gaver, 2004). Sengers (2005) states "Ludic design promotes engagement in the exploration and production of meaning, providing for curiosity, exploration and reflection as key values".

Critical Technical Practice is proposed by Agre (1997) and is grounded in Artificial Intelligence. It is an approach embracing critical reflection on basic assumptions that might negatively affect technical progress. Agre states that:

> I wish to investigate this confluence of technology and human experience. The philosophical underside of technology has been deeply bound up with larger cultural movements, yet technical practitioners have generally understood themselves as responding to discrete instrumental "problems" and producing technologies that have "effects" upon the world…. I would like to contribute to a *critical technical practice* in which rigorous reflection upon technical ideas and practices becomes an integral part of day-to-day technical work itself.

Boehner (CTP) points out the typical moves in Critical Technical Practice:

> … identifying the core metaphors of the field, noticing what, when working within those metaphors, remains marginalized, inverting the dominant metaphors to bring that margin to the center, and embodying the alternative as a new technology. … during this process, the values embodied by the field can be questioned and shifted.

Finally, Schon (1983) discusses the epistemology of practice with respect to "reflection-in-action" and states that:

> When someone reflects-in-action, he becomes a researcher in the practice context. He is not dependent on the categories of established theory and technique, but constructs a new theory of the unique case...He does not separate thinking from doing… because his experimenting is a kind of action, implementation is built into his inquiry. Thus reflection-in-action can proceed, even in situations of uncertainty or uniqueness, because it is not bound by the dichotomies of Technical Rationality.

Critical Technical Practice enables us to reconsider our choices and basic assumptions and to negotiate our values. It allows us to link particularity, uniqueness and uncertainty to our research practices and to explore the limits of interaction design practice and new forms of assemblages among people, machine and environment.

Parallel to these critical and ludic design approaches, we will apply a critical reflective design and evaluation methodology. As a result of this, the purpose of our design will not be to propose a usable, effective, single meaning system but to provide a system that treats the users of system as performers. It will allow those performers to play with other machine artefacts in a mixed reality space for creation and exploration of meaning and agency, for co-constructing new agent assemblages and for having new ways of looking at world. Similarly, our evaluation does not focus on determining whether an authoritative interpretation was successfully communicated but on identifying, coordinating, stimulating, and analysing processes of interpretation in practice.

3.1. Wearable Environments

The main motivation of our wearable environment system is to unify technologies of self (as wearable computing) and technologies of environment (as smart environments) through a phenomenological perspective. Although the idea of combining these two technologies is not new (Rhodes et al, 1999), the general tendency is to resolve the issues associated with any of them when used as a single a technological solution. For example, typical problems are related to maintaining the personalized information and privacy concerns for ubiquitous computing; and resource management, localized control and limited computational capability for wearable computing technologies. However, if we look at the ways to couple these technologies not to resolve technical insufficiencies but to evoke new relations focusing on human experience, this will open a new area full of potential for inquiry and experimentation of agencies of human, machine and environment.

In order to achieve this goal, we focused on the unique affordances of these two technologies and tried to combine the features of each that can allow co-construction of agencies and experiences. Here, we narrowed our focus on emotional and sensual aspects of experiences that are part of our agency. The unique affordances of each of these technologies:

Smart Environments	**Wearable Computing**
. Localized Info. & Control	. Mobile Info. & Control
. Remote Interaction	. Proximate Interaction
. Generic User Interface (for multiple people)	. Personal User Interface (for a single person)

The wearable environment will benefit from the affordances of these two by unifying them into a single hybrid interface to enrich emotional experience of people in that environment.

Wearable computing is suitable for proximate and intimate types of interaction with the body of the wearers and is advantageous both for capturing the expressions (as input of the system) and for converting the expressions (as output of the system). Smart environments with their localized and central control and their ambient sensing and diffusing mechanisms are suitable for mediating agent communication, gathering physical context data (temperature, light level, crowd gestures etc.) and broadcasting any expressions. In this context, we determined two main features that can support the co-creation of emotional experience and meaning making: *amplified expressions* and *augmented senses.*

Amplified expressions are the expressions that are sensed by wearable computing and then conveyed to other wearable computers or broadcasted to ambient diffusers by smart environments. Here, while wearable computing takes advantage of being attached to the wearer's body and senses his/her bodily expressions (heart rate, breath, galvanic skin response, body movement etc.), the smart environment takes advantage of central control of resources and its general user interface.

Augmented senses are the senses that are powered by the sensing mechanisms embedded into environment. The smart environment continuously senses the physical properties of the space and can deliver this sensed spatial information to the wearable computers where they are converted to the different types of emotional outputs to be felt by the wearer.

These two main features of the wearable environment system and the flow of expressions are depicted in Figure 5.

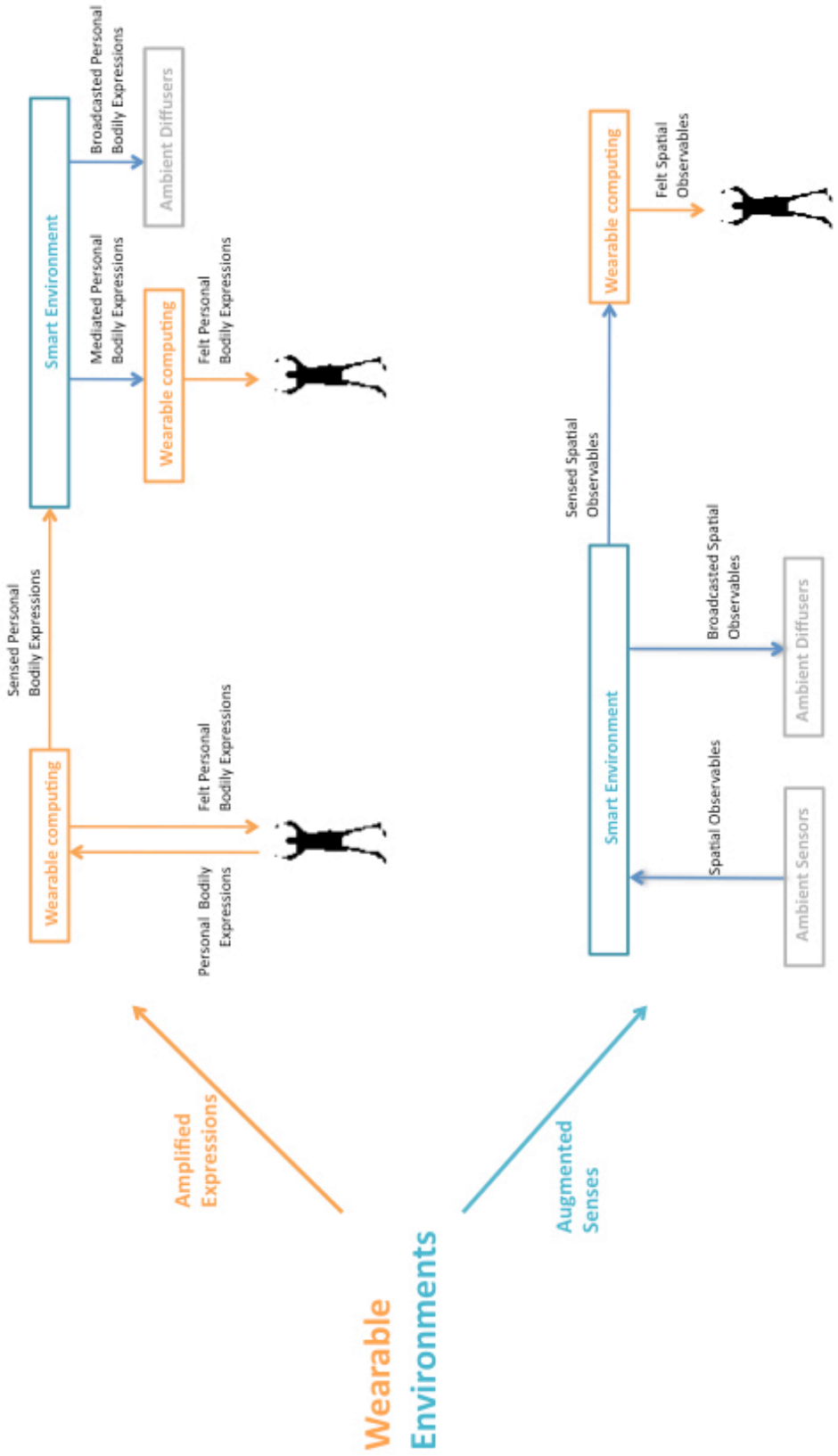

Figure 5 Wearable Environment Framework Structure and the flow of expressions

The system will work as an affector system (Boehner et al, 2008), as an additional channel that allows extra meaning making. The expressions and emotions will be used to evoke new emotions and relations. The aim is not to codify or formally represent and accurately transfer the affect but to allow people to construct it. The system will facilitate the experimentation and investigation of self-expression, meaning generation, shared agency and interconnection with others and the environment emotionally.

Capabilities of wearable computing component

- **Sense**: It can sense various body related expressions.
- **Actuate**: It can provide various haptic outputs to be felt by the wearer(s).
- **Diffuse**: It can diffuse various visual or sonic outputs to be heard or observed by wearer(s).

Capabilities of smart environment component

- **Sense**: It can sense various physical conditions of space.
- **Convert/map**: It can convert one type of sensed data to another type and can map the output of one agent to input of another agent.
- **Diffuse**: It can diffuse various visual or sonic outputs to the environment by ambient diffusers.
- **Mediate**: It can direct the expression of one wearer to another one or broadcast it to any of the ambient diffusers. It can allow the wearable computer to direct its expression to itself. It facilitates the emotional communication and negotiation of the system.

The system will work as an affector system (Boehner et al, 2008), as an additional channel that allows extra meaning making and as an investigation tool for the levels of agencies of human and non-human agents. The aim is not to codify or formally represent the affect/the expression but to allow people to construct them. The system will facilitate the experimentation and investigation of agency, self-expression, meaning generation, and extension toward others and toward environment emotionally.

3.2. Stages of Research

This research will follow a cyclical structure of development where each phase on the cycle will feed the next phase and also will serve to the same phase of the next cycle as revisions. Figure 10 shows the alignment of our research with the continuous cycle of technological, conceptual, and methodological developments.

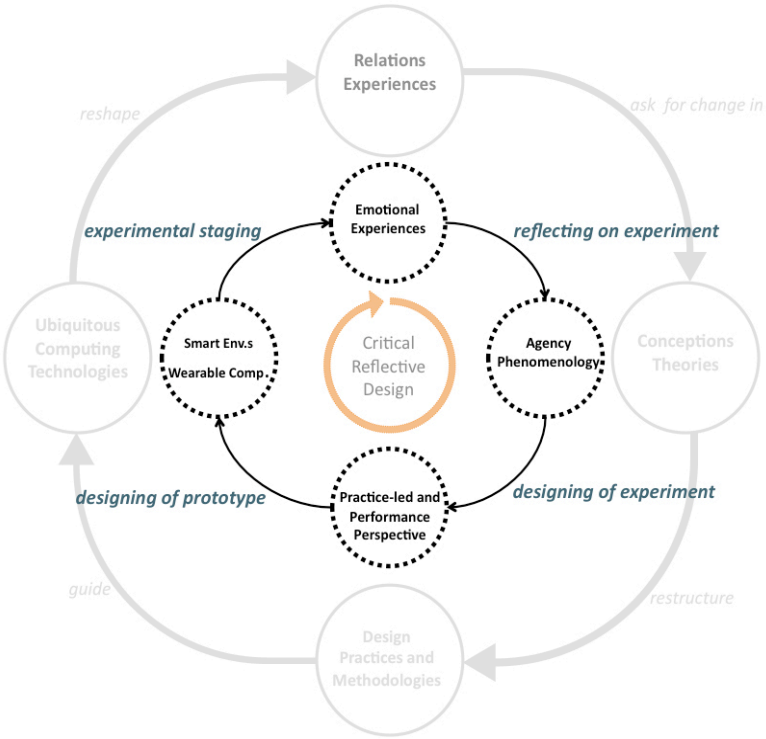

Figure 6 Research cycle

The cyclical process illustrated in Figure 6 constitutes a critical reflective design practice. We will begin the cycle by establishing a theoretical base by agency and phenomenology and use this as a foundation to design our initial experiment from a performance perspective. A prototype system will be developed to enable the staging of the experiment using a combination of Smart Environments and Wearable Computing technologies. Finally, we will reflect on the outcomes of the staged experiment. This reflection will guide the revisions on our initial assumptions and aims for the start of the next research cycle.

In total, we will complete three cycles during the research: a preliminary case study, performative case study 1, and performative case study 2. The first of these cycles, involving the preliminary case study, has already been completed.

The motivation behind the preliminary case study was to explore the varieties of agency by physically coupling with the environment in unusual ways and to reflect on the experience of participants during this experimentation. At the end of the study, we derived a set of research themes and descriptions of potential participant experiences of different agent assemblages.

This preliminary case study served as a conceptual inquiry of initial ideas. We were able to derive useful insights and inspirations that resulted in the conception of wearable environments. The details of this study will be explained in the Section 4.

Before each of the performative case study, there will be consultation sessions formulated as focus groups consisting of 4 to 6 professionals from performance and performance studies. We will obtain some crucial knowledge about assumptions, goals and initial design choices using in-depth interviews and short experimentations. We will determine the particular types and distribution of technological interface agents (i.e. sensors and effectors) during these sessions. The total time for a consultation group session will be about 4 hours. First half of the session will be discussions and the second half will be the experimentation of interface agents. In the first part, we will ask open-ended questions about the assumptions, conceptual framework, non-verbal ways of expression and negotiation, and the bodily gestures that can be empowered by interactive artefacts. In the second experimentation part, we will determine a core set of interface agents and their integration ways with the participants. The whole session will be audio recorded. The outcomes of these sessions will inform the design of case study 1.

Performative case study 1 will investigate basic notions of agency and the relation between different agent assemblages/configurations and levels of agency. Human experience of those relations will guide our design and evaluation methodologies. We will begin to look for the ways to support negotiation processes between human and non-human agents by experimenting different levels of system agency and different degrees of agent associations/configurations. At this stage of the study, our negotiation process will be based on simple turn taking principle. System agency and agent configurations will be explained in detail in the next section.

Before commencing performative case study 2, will revise our assumptions, design methodologies and evaluation methods according to the outcomes of the previous cycle. We will also introduce support for more advanced negotiation processes between agents, in particular, to allow for simultaneous communication.

3.3. Design and Evaluation Framework

Our initial design and evaluation framework consists of following control dimensions: modes of negotiation, levels of agency within the system and types of integration between the human and non-human agents. Negotiation modes will be used to determine the communication protocol between all the agents. These protocols of communication define the ways and rules for sharing information. How do agents send and receive messages or expressions? In what order will this communication be handled? While at the first case study, the negotiation mode will be based on simple turn taking principle; at the second one there will be a more advanced way of negotiation process between the agents, which allows the simultaneous communication between them.

The other two dimensions, the system's agency levels and integration types of agents were derived from the distributed agency framework proposed by Rammert (2008) and the operational modes for wearable computing suggested by Mann (2001). System's agency at level 1 corresponds a system with re-active behaviour, and at the level 2 a system with pro-active behaviour. There will be two types of technological interface agents in the form of sensing and effecting (either actuating or diffusing) agents; and two modes of integration between those interface agents and human body as proximate and distant. Examples of sensing agents would include accelerometers, pressure pads or skin conductance sensors. Examples of effecting agents might include projectors, lights or vibration motors. These sensing and effecting agents will be distributed into the environment according to their distance to the human body. The agents placed on the human body will be included to the proximate mode such as a skin conductance sensor and the agents placed or embedded into the environment will be included to the distant mode such as speakers hanged on to the walls. The selection of the particular types of agents and their distribution will be determined in the consultation sessions. All of these dimensions for case study 1 and case study 2 can be seen in Table 3.

		Negotiation Mode 1				Negotiation Mode 2			
		System's Agency Level 1		System's Agency Level 2		System's Agency Level 1		System's Agency Level 2	
		Sensing Agents		Sensing Agents		Sensing Agents		Sensing Agents	
		Proximate	Distant	Proximate	Distant	Proximate	Distant	Proximate	Distant
Actuating/ Diffusing Agents	Proximate	1	2	5	6	1	2	5	6
	Distant	3	4	7	8	3	4	7	8
		Case Study 1				Case Study 2			

Table 3. Design control dimensions for case studies

The numbers in each uncoloured rectangle box, that is**,** experiment sessions, denote a particular configuration between the human and non-human agents. For instance, #1 corresponds a configuration in which both sensing and effecting agents are placed on the body as wearables with level 1 system agency. Similarly, #7 corresponds a configuration in which sensing agents are placed on the body but the effecting agents are placed into the environment with level 2 system agency. Here, an effecting agent such as a projector will be carried by the wearer in the configuration #1 whereas will be embedded into the environment in the configuration #7. All the configurations in case study 1 work under negotiation mode 1.

The proximate and the distant modes of integrations are able to support all three directions of expressions: from self to self, from self to other and from self to environment. For instance, in the configuration #1, the expressions captured by a proximate sensing agent can be sent back to the wearer if the proximate effecting agent is a vibration motor (self to self) or they can be sent to the environment if the proximate agent is a portable projector (self to environment). Here, the direction of expression is determined by not only the placement of the agent but also the particular functionality of the agent. For this reason, we can say that the direction of an expression is determined by a specific configuration/assemblage between the types of the agents and their physical placement.

Although, It is possible to cover all three directions of expression, we will implement and test only “self to self” and “self to environment” directions due to the scope limitations. The reason for eliminating the “self to other” direction is that it involves design and implementation tasks largely different from the other directions.

At the next sub-sections, the details of Rammert’s and Mann’s frameworks will be explained and the links between our research study and them will be presented.

Levels of Agency:

Rammert (2008) defines three levels of agency and various degrees of capabilities on these levels as seen in Table 4. At the first level, there is *causality* where there is a weak term of action without requiring consciousness. These are mostly automated and repetitive tasks. At this level, the highest degree of agency might be restructuring of action due to the greater irritation or

availability of more options. At the second level, there is contingency that requires the capacity to act in a different way when the conditions for the routine action change. Here, the degree of agency starts from the selection of pre-selected options to the self-generation of actions. Finally, at the third level, intentionality that requires reflexive and intentional action oriented to the supposed meaningful action of other actors. The degree of agency at this level corresponds to the ascriptions of simple dispositions to the guidance by complex semantics.

Reflective Engagement

Transparent Engagement

Levels	**Low**	***Degrees***	**High**
L3: Intentionality	From ascription of simple dispositions	…	Up to guidance by complex semantics
L2: Contingency	From selection of pre-selected options	…	Up to self-generation of actions
L1: Causality	From short time irritation	…	Up to permanent re-structuring of action

Table 4. Levels and grades of agency (Rammert, 2008)

While a higher level of agency signifies a reflective mode of engagement, a lower level agency is associated with transparent modes of engagement. Rammert also suggests that we can analyse two main modes of integration between human and technology: hierarchical mode whereby specialized activities are strongly integrated and an interactive mode whereby distributed modal units are weekly coupled. They differ in how the units are divided, how they are processed, and how they are connected with one another. Rammert points out "the framed interactivity mode is rarely implemented because it deviates from the well-known and trusted master-slave relation". We see that hierarchical mode and framed interactive mode correspond to the lower level and higher level of system's agency respectively. The different properties of each mode can be seen in Table 5.

MODES:	HIERARCHY	FRAMED INTERACTIVITY
Type of Differentiation	Division of work Functional specialization	Distributed activities Fragmented units
Type of Organization	Mechanical Bureaucratic	Organic Open System
Type of Connection	Linear sequences Strongly coupled Fixed and general rules Pre-Programmed	Parallel processes Loosely coupled Flexible, situated and specific rules Framed Self-adaptation

Table 5. Two modes of integration (Rammert, 2008)

In our design, we will have a system with only two-levelled agency. We will not deal with the system's agency at level 3 that requires various grades of intentionality, which requires a separate research study alone. At the system agency level 1, there will be a tightly coupled and rigid system working in a re-active fashion guided by pre-programmed and fixed rules. At the system agency level 2, there will be a flexible system in which technological units will have higher levels of agency advanced by artificial intelligence to interact. While the system will not have level 3 agency, this level of agency is the most important part of the human agency involving different degrees of intentionality. Thus, It will be a vital part of the evaluation process.

Operational Modes:

The operational modes are related specifically with wearable computing technologies proposed by Mann (2001). According to him, there are three operational modes: constancy, augmentation and mediation. In constancy mode, wearable system is always on and interactionally constant- that is the device's inputs and outputs are always perceptible. In augmentation mode, users are engaged with their actual task or activity without paying attention to wearable computing which seamlessly augments or supports that activity. This mode corresponds to the transparent mode of engagement. Finally, in the mediation mode, wearable system encapsulates the user in various degrees. It can act as an information filter (aspect of solitude) for unwanted information or experiences or as a protector (aspect of privacy) for personal information to be accessed. These modes are depicted in Figure 7.

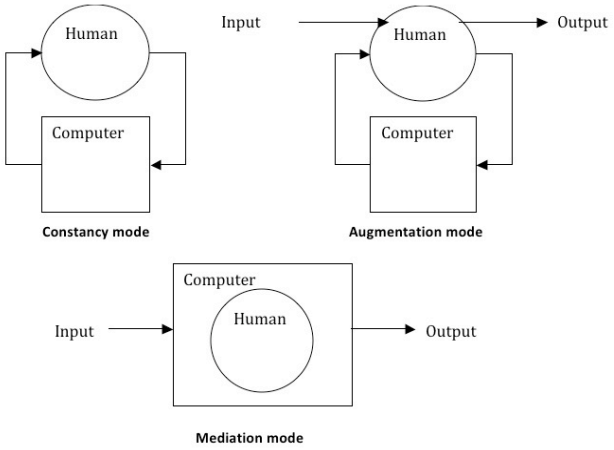

Figure 7. Operational modes for wearable computing systems (Mann, 2001)

Although, these modes are useful for categorizing possible modes of relations between user and wearable system, they are mostly targeted for head-mounted display type of wearable computing technologies. Since, our wearable system will not utilize this display technology and our system will not be just a stand alone wearable computing system, we will use these modes as reference to define and position our own modes of the system. In addition to these modes, Mann defines 6 attributes for wearable computing.

- Unmonopolizing (of the user's attention)
- Unrestrictive (to the user)
- Observable (by the user)
- Controllable (by the user)
- Attentive (to the environment)
- Communicative (to others)

In order to use these attributes as a framework for defining the design and evaluation framework for our wearable system, we re-represented them as continuous dual scales. By this way, we can define each attribute of a wearable system on a qualititative scale, please see Figure 8.

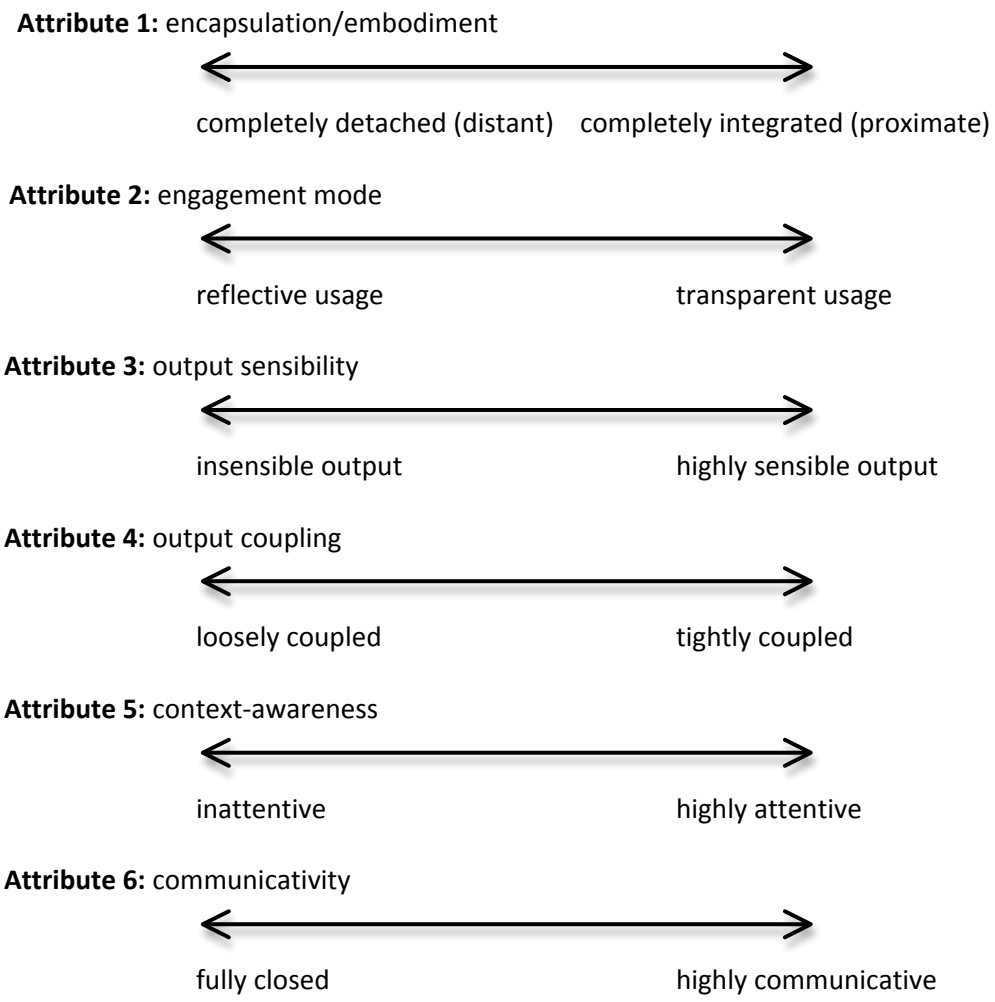

Figure 8. Wearable computing system attributes as qualitative continuums

For instance, observable attribute can be represented as a sensibility continuum that shows the sensibility degrees of system's output. Vibrations of a vibration motor attached to the human body is almost always sensible, so it corresponds to a high degree of sensibility whereas a projected video image in some cases might not be in the area of visibility of the participant so it corresponds to relatively a lower degree of sensibility. Similarly, controllable attribute can be represented as an integration/coupling continuum that shows the amount of coupling between the user action and system response.

We will use the attributes 1, 4 as design control dimensions together with the negotiation mode and the attributes 2 and 4 as evaluation assessment dimensions for the agency. The attributes 5 and 6 will be used as set to highly attentive and highly communicative.

Design dimensions:

Negotiation modes:

There will be two modes of negotiation. First mode will be based on simple turn taking principle between the agents (human participant and the system) and will be experimented in case study 1. The second mode will be based on a more advanced way of negotiation supporting simultaneous communication between the agents.

Attribute 1: encapsulation/embodiment

This attribute defines the degree of encapsulation of human by the computer system. We will have two modes of encapsulation/embodiment: proximate mode in which sensing or effecting interface agents will be placed on the body and distant mode in which interface agents will be placed into the environment detached from the human body. We will experiment four different combinations between the sensing and diffusing agents with respect to distant and proximate modes.

Attribute 2: controllability/output coupling

This attribute is directly related with the level of system's agency and the modes of integration proposed by Rammert (2008). We will have two modes or levels of system's agency to control this attribute. While at the first mode, the system is a simple rule-based and re-active system, at the second mode the system can act in a pro-active way.

Evaluation dimensions:

Attribute 3: engagement

This attribute defines various modes of engagement from transparent mode in which humans use computer as a tool corresponding to Heidegger's notion of "ready-to-hand" to the reflective mode in which human and computer are in a dialogue corresponding to Heidegger's notion of "present-at-hand". While transparent mode signifies lower levels of agency, reflective mode indicates higher levels of agency.

In order to assess the engagement and further the level of agency, we will combine the Rammert's (2008) framework for distributed agency with Bilda et al's (2008) model for creative engagement. Intentionality corresponds to the highest level of agency at the Rammert's framework and at this level there are degrees of intentionality from ascriptions of simple dispositions to the guidance by complex semantics. Rammert provides only a general reference for the intentionality at this level, which is not sufficient for assessing the different degrees of intentionality of human participants. For this reason, we will integrate the interaction modes related to intentionality from Bilda et al's model for creative engagement. They identified five different modes of interactions: unintended, deliberate, intended/in control, intended/uncertain, and unexpected.

Unintended mode refers to the initial interaction with a system or environment where user expectations are not set. Users try to figure out system's purpose and how it works.

Deliberate mode refers to a stage where user knows a little of what to expect and starts to develop ideas about possible capabilities of system.

Intended/in control mode refers to a stage where the user is capable of setting a purpose for his/her actions and expectations about the outcomes.

Intended/uncertain mode refers to a stage where the audience starts expanding her/his intentions for her actions and expectations about the outcomes. In this mode, user can set intentions but uncertain about the outcomes. This mode is the one that has the highest possibilities for creative engagement, where the user can end up with creative outcomes or can reflect in action.

Unexpected mode refers to a stage where the users question their intentions, expectations about outcomes and what the system is about. Users do not feel in control of the system and it becomes hard for them to set out an intention and what to expect. Bilda et al point out that this mode has the highest risk for frustration and the highest potential for

creative outcomes and influential experiences. This is also the most reflective mode of engagement.

We will assess the levels of agency by means of the distributed agency framework by Rammert (2008) and degrees of agency at that level by means of creative engagement model by Bilda et al (2008).

Attribute 4: output sensibility

This attribute defines the degree of sensibility of system's output. It is an important attribute playing a critical role in formation of agency of humans. Higher levels of sensibility of self and environment are expected to result in higher levels of agency. Although, our main focus is not on controlling or assessing the output sensibility, we will investigate the possible relations between the degrees of sensibility and levels of agency.

Execution of case studies:

Performative case studies will consist of a series of 8 sessions corresponding to 8 configurations in Table 3. There will be a short introductory session for each participant before the main sessions to explain the working principles of system's interface. In addition, there will be one testing session before the execution of all experiment in which a suitable amount of duration for each session will be determined. Initially, we estimate that each session will last 20-30 minutes. Since we focus on the first person experience of these systems and value for uniqueness and particularities as well as the commonalities, we will investigate the experience of few people in more detail rather than gathering less detailed information from a larger population. For this reason, we will recruit a total of six participants. There will be one participant for each session. The participants will have an initial session for getting to know the system. We will recruit expert people who are familiar with interactive media art systems and interaction design research field. The participants will be informed about the experiment aims and objectives in detail to allow them to reflect-in-action.

All experiment processes will be video recorded for the retrospective reporting (video-cued recall). The questions of interview will allow the performers/users to reflect on their

experiences. After this interview phase, we will critically reflect on the outcomes by a synthesis phase. We will evaluate the outcomes of the session with respect to our design goals and assumptions. Then, we will do an action plan considering the things that we can improve in the next iteration of the study and identifying the needs of feasible improvements.

4. Preliminary Case Study

4.1. Motivation

The motivation behind this preliminary case study is to explore the different levels of agencies by physically coupling with the environment in unusual ways. The main assumption of this exploration is that agential capabilities of the agents (humans and artefacts) in relation are not fully exploited; and existing conventions on relations between the agents prevent the emergence of new agential capabilities and associations. The underlying claim in this experiment is that experimenting unusual ways of physical couplings allow us to escape from those conventions and consequently is helpful for investigating the varieties of agencies.

4.2. Execution Process of Preliminary Case Study

Two performers were knowledgeable about the motivations of the study. The environment was chosen according to its potential of providing a range of surfaces to be related, to be touched and to be coupled. One performer was female at age 25 and the other one was male at age 30. They were not professional performers but were familiar with the contemporary performance art works.

One of the performers with the digital camera was the observing performer and the other one who was to couple with environment by touching was the observed performer. The observing performer had the role of guiding the other performer to position her body according to some simple heuristics, which might facilitate having extraordinary forms[1] of relations with the environment. One of these heuristics was to try to maximize the contact surface with the environment. It is somehow the opposite of our general everyday life practices in which we mostly try to minimize the closer and intimate physical connection with the surrounding space. Another one was the physical comfort factor of the performer. The observed performer in most cases touched to environment where she felt little or no physical pain and was comfortable in

[1] Here extraordinary forms refer both the quality of perception of the relation with regards to evoking some unique and idiosyncratic experience for each of the performers and the quality of visual assemblage with regards to its aesthetic value and its capacity to promote meaning generation.

her position. The aesthetic value of the coupling of human body and environment was another guide for the performance. The performer with the digital camera respected this aesthetic aspect since he had a chance to observe the form of that coupling in whole and from various point of views. One of the heuristics that is somehow different from the others was about mimicking human's intimate process of getting to know each other by touching. The logic behind this heuristic was that it could allow the performer to escape from pre-established ways of approaching to the environment by considering it as if it was the first time they were touching to each other. Performers in most cases verbally negotiated to decide the suitable place of contact and the final position of body with that contact surface. After positioning the body of the performer, the other performer with the digital camera searched for various points of views to capture this coupling such that the resulting image satisfies some of the criteria. The experiment was conducted over about a period of 4 hours at the Rocky area of Coogee in Sydney. The only digital technology used was a DSLR digital camera.

Two performance experiments were executed. The processes of those experiments were the same except the change of roles of the performers. They simply switched their roles. The aim of this change was to facilitate empathy between the performers and to increase the chance of obtaining different forms of relations, blends and to identify some of the differences between the performer's interpretation of the performance aims and their approach to deal with those aims.

4.3. Outcomes and Reflection

Experiment 1:

Figure 9 Photographs from Experiment 1

The photographs in Figure 9 captured the same situation from two different viewpoints. Moving the viewpoint from one place to another resulted in dramatically different percept of relations. While the camera's viewpoint of the first picture reveals the performer's position, in the view of the right image the performer's body appears to be merged with the environment. This merge was produced out of the 3rd person view of the performer with the digital camera. He visually blended the forms of human body and forms of rocks, which created a visual amalgamation and kind of hybrid form between human and environment. A negotiation process between the performers was required to make this blend 'seamless' [1].

This temporary amalgam provokes our thinking of the idea of wearable environment. It is co-created and co-performed by the agencies of the observing performer and the observed performer. This case demonstrates the significance of establishing and combining alternative points of views for the creation of meaning and agency in performed interactions.

Taking this experiment as a starting point, how would a performer be able to experience this hybridization [amalgamation] process during the course of the performance from a 3rd person

[1] In fact, the final form is not only seamless but also seamful. It is seamless because the form of human body and the forms of rocks are perfectly fitted and sculpted and it is seamful because we can still recognize the joints between two

point of view? How would this change her experience? How would this change her agency? How would this facilitate / extend a negotiation between performer, environment and observer?

Experiment 2:

Figure 7 A photograph from Experiment 2

The above photograph from the second case study shows a hybrid relation between the performer and environment. This time, the agency of the environment seem to have a more dominant effect on the resulting formation by extending itself onto human body by smoothly following the curves of the body as if imitating the blood vessels under the skin. An important outcome of this case study is that it demonstrates how the environment can be extended to and become part of the human body. We can begin to think about the implications of perceiving the environment not as surrounding our body and us but rather as dynamic extensions of our body. How would this affect our agency, our experience and our awareness of our bodies and the relationships we create with other entities?

Emerging Themes:

Multiple points of views and Reconfiguration: The most important theme emerging from the case studies was the significance of multiple points of views in searching for agencies and in meaning-making activities. Having multiple points of views produces a new layer of experience and analysis by providing additional agency that can further blend the existing assemblage. Multiple points of views are a way of reconfiguring the existing network of agents where all agents are connected to each other.

Hybridization and blending: Hybridization and blending happens when human body and environment are coupled in such a way that resulting form demonstrates the characteristics of two. Parts of the environment merges with human body or vice versa like in the first performance experiment. They are overlaid or blended onto each other by the performing agents' own agencies or through the agency of observer. Blending of agencies might open up new possibilities for investigating the agential assemblages.

Interconnectedness: This theme is related to first person experience obtained from coupling with environment. Performers felt intimate experiences resulting in deeper levels of awareness and feeling of connectedness for their own agencies in relation with the environment and the observer.

Empathy: Performers switched the roles of observing and performing during these experiments. This enables them to develop an empathy, which gives an access to first person experience of each other in some degree.

Negotiation: The negotiation between the performers was a vital part of the experiment, which allows them to co-construct the meaning/performance and sculpt the visual amalgamation. This makes negotiation one of the major aspects shaping our agency. Negotiation will be a vital part of the future experiments.

5. Work Plan and Resources

In this section, I will first introduce my work plan by a Gantt chart together with explanations for each development phases and then I will present my resources that will be needed for the development and execution of the experiments.

5.1 Work Plan

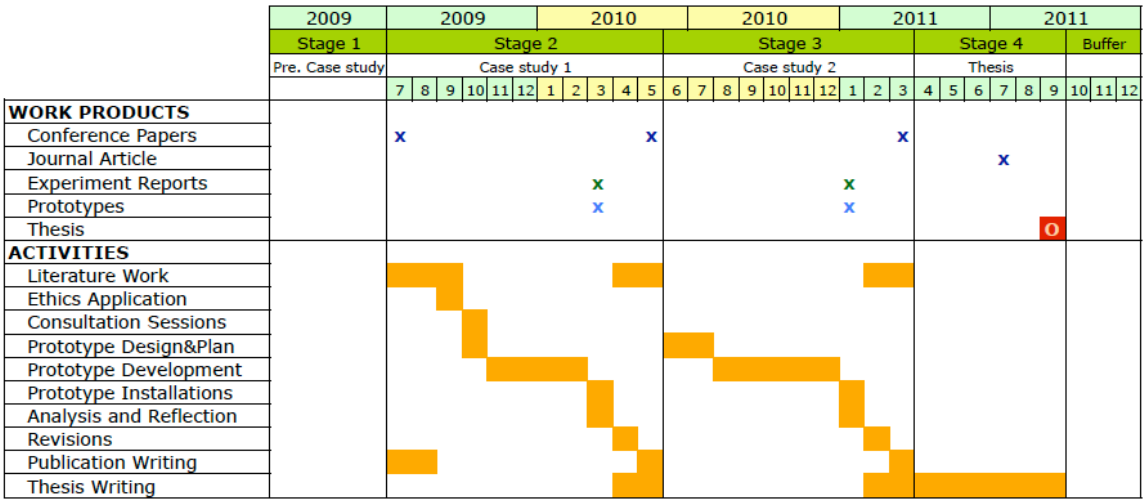

Table 6. Gantt chart of Research Study

The above Gantt chart shows the time plan for the research. The Stage 1, involving the preliminary case study, has already been completed. The explanations of activities in the next stages are as follows:

Stage 2: **Case Study 1** (11 months)

- First publication writing: A conference paper, which will present the research study and summarize preliminary performance experiment, will be written.
- Ethics application for workshops: Ethics application for Case Study1 will be prepared and submitted.
- Literature work: A further literature study will be done. The following topics will be investigated:
  - Multi-agent systems
  - Multi Sensor systems
  - Phenomenology of perception
  - Laban Movement notation
  - Performance Studies (Staging, constraints, masks, improvisation etc.)
  - Actor-network theory and activity theory
  - Philosophical discourse on agency
- Consultation Sessions: A focus group study with performers will be done.

- Thesis writing: The process and outcomes of two studies will be integrated into the thesis document.
- Ethics application: Ethics application for the next case study will be prepared and submitted.
- Prototype installation-1 design and planning (PI-1): Prototype software and hardware infrastructure for PI-1 will be designed and performance scripts, place, materials, equipments will be determined.
- Prototype installation-1 development: Prototype software and hardware infrastructure for PI-1will be implemented, participants will be recruited and performance logistics needs will be covered.
- Prototype installation-1 execution: PI-1 will be held in two parts in a period of two weeks.
- Analysis and reflection on PI-1: The process and outcomes of PI-1 will be analysed and reflected in and on. The research themes, design criteria, agent couplings, participant engagement, affect and varieties of agencies will be evaluated and any revisions about the underlying concepts and framework will be done.
- Literature work: Additional literature work will be done if needed.
- Second publication writing: A conference paper, which will present the research study and summarize the outcomes and processes of preliminary performance experiment and workshops and PI-1, will be written.
- Thesis writing: The process and outcomes of PI-1 will be integrated into the thesis document.

Stage 3: **Case Study 2** (9 months)

- Prototype installation-2 design and planning: Prototype software and hardware infrastructure for PI-2 will be designed and performance scripts, place materials, equipments will be determined.
- Prototype installation-2 development: Prototype software and hardware infrastructure for PI-2 will be implemented, participants will be recruited and performance logistics needs will be covered.
- Prototype installation-2 execution: PI-2 will be held in two parts in a period of two weeks.
- Analysis and reflection on PI-2: The process and outcomes of PI-2 will be analysed and reflected in and on. The research themes, design criteria, agent couplings, participant engagement, affect and varieties of agencies will be evaluated and any revisions about the underlying concepts and framework will be done.
- Literature work: Additional literature work will be done if needed.
- Third publication writing: A conference paper, which will present the research study and summarize the outcomes and processes of preliminary performance experiment and workshops and PI-2, will be written.
- Thesis writing: The process and outcomes of PI-2 will be integrated into the thesis document.

Stage 4: **Thesis Writing** (6 months)

- Literature work: Additional literature work will be done if needed.

- Fourth publication writing: A journal article, which will present the research study and explain all the case studies and their outcomes, will be written.
- Thesis writing: The whole thesis structure will be constructed, new sections will be added (if needed) and separate chapters will be integrated.

5.2 Resources:

In this section, the resources that will be used in our research will be presented. These are hardware and software and human resources.

Hardware resources: Projectors, video cameras, various sensors, actuators, LED screens, light sources, few garments and a server computer will be needed as hardware resources.

Software resources: There are many software infrastructures available for the development of multi-agent systems. Metaglue, Hive and Gaia are three useful candidates that will be investigated in detail.

Human resources: 6 participants will be needed for performative case studies.

Projectors, video cameras and server computer can be obtained from ICT. Various sensors, actuators, few garments, LED and light sources will be procured.

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