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Machine Performers: Agents in a Multiple Ontological State

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Machine Performers: Agents in a Multiple Ontological State

by

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Copyright Statement

Abstract

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Keywords: *robotic art, embodiment, performing arts, artificial intelligence, presence on the stage, agency.*

In this thesis, the author explores and develops new attributes for *machine performers* and merges the trans-disciplinary fields of the performing arts and artificial intelligence. The main aim is to redefine the term "embodiment" for robots on the stage and to demonstrate that this term requires broadening in various fields of research. This redefining has required a multifaceted theoretical analysis of embodiment in the field of artificial intelligence (e.g. the uncanny valley), as well as the construction of new robots for the stage by the author. It is hoped that these practical experimental examples will generate more research by others in similar fields.

Even though the historical lineage of robotics is engraved with theatrical strategies and dramaturgy, further application of constructive principles from the performing arts and evidence from psychology and neurology can shift the perception of robotic agents both on stage and in other cultural environments. In this light, the relation between representation, movement and behaviour of bodies has been further explored to establish links between *constructed* bodies (as in artificial intelligence) and *perceived* bodies (as performers on the theatrical stage). In the course of this research, several practical works have been designed and built, and subsequently presented to live audiences and research communities. Audience reactions have been analysed with surveys and discussions. Interviews have also been conducted with choreographers, curators and scientists about the value of *machine performers.*

The main conclusions from this study are that *fakery* and *mystification* can be used as persuasive elements to enhance agency. Morphologies can also be applied that tightly couple brain and sensorimotor actions and lead to a stronger stage presence. In fact, if this lack of presence is left out of human replicants, it causes an "uncanny" lack of agency. Furthermore, the addition of stage presence leads to stronger identification from audiences, even for bodies dissimilar to their own. The author demonstrates that audience reactions are enhanced by building these effects into

machine body structures: rather than identification through mimicry, this causes them to have more unambiguously biological associations. Alongside these traits, atmospheres such as those created by a cast of machine performers tend to cause even more intensely visceral responses.

In this thesis, “embodiment” has emerged as a paradigm shift – as well as within this shift – and morphological computing has been explored as a method to deepen this visceral immersion. Therefore, this dissertation considers and builds *machine performers* as “true” performers for the stage, rather than mere objects with an aura. Their singular and customized embodiment can enable the development of non-anthropocentric performances that encompass the abstract and conceptual patterns in motion and generate – as from human performers – empathy, identification and experiential reactions in live audiences.

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September 15th, 2014

AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee. Work submitted for this research degree at the Plymouth University has not formed part of any other degree either at Plymouth University or at another establishment.

The studies and the production of *The Tiller Girls, Area V5* and *The Blind Robot* were partly financed with the aid of research grants from the Nanyang Technological University (Singapore). *La Cour des Miracles* was originally created under a Canada Arts Council grant. The Museum of Civilisation of Quebec City (Canada) commissioned *Area V5*. The Australian Dance Theatre commissioned *Devolution*.

My research and artwork has been presented at several cultural events and academic and scientific conferences. I have also given several keynote talks, presented several performance and installations at international venues, and received several prizes and mentions for artworks included in this dissertation.

Publications

Demers L.P., Vorn B., ”Schizoid Ontologies of Cybernetic Lures”, to appear in “Euphoria / Dystopia: The Banff New Media Institute Dialogues” edited by Sara Diamond, Sarah Cook, The Banff Centre Press/Riverside Architectural Press, Fall 2011.

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Demers L.P.,”Towards an Understanding of Staging Robots”, Montreal Planetarium College Summit, April 2007.

Demers L.P., "Anthropocentricity and the Social Robot: Artistic and Aesthetic Investigations into Machine Behaviours", Proc. of 50th AI Summit, Switzerland, 2006.

Exhibitions and Performances

	Area V5, an interactive robotic installation, commission
2009-10	Museum of Civilisation, Quebec City (Canada)
2010	Human+, Science Gallery (Trinity College – Dublin)
2013	Human+, Tekniska Museet (Sweden)
	The Blind Robot, interactive robotic installation commissioned by Robots&Avatars, National Theatre (London)
2014	Moscow Robo Show&Forum “Bal Robotov” (Moscow)
2014	Digital Arts Biennale, Contemporary Arts Museum (Montreal)
2014	Art Rock (France)
2014	Aalborg University (Denmark)
2014	Phaeno Science Museum (Germany)
2013	Ars Electronica Exhibit, ITU Telecom Worldcongress (Bangkok)
2013	The Media of Science (Luneberg)
2013	Ars Electronica (Linz)
2013	Fact (Liverpool)
2013	AltArt, Cluj-Napoca (Romania)
2012	European Capital of Culture 2012, Maribor (Slovenia)

La Cour des Miracles, installation,
2012 Retrospective of VIDA (Artificial Life Contest), **Telefonica** (Madrid).
2014 Woodstreet Galleries (Pittsburgh)

The Tiller's Girls, robotic performance,
2010 VIDA 12.0 – video screening (Madrid)
2010 Cyberlabor, Theatre St-Polten (Austria)
2010 Bains Numeriques (France)
2010 V2 (Rotterdam)
2011 Elektra (Montreal)
2011 Winzavod (Moscow)
2011 Winzavod (Moscow) – video screening/installation
2011 Robot Film Festival (NYC) – video screening
2011 Belgrade Summer Festival (Belgrade)
2011 Centre 104 (Paris)
2012 Soft Control, European Capital of Culture 2012, Maribor (Slovenia)
2012 Soft Control, Maribor (Slovenia) – video screening/installation
2013 Robots on Tour (Zurich) – video screening/demonstration

DEVOLUTION, robotic & dance performance,
Garry Stewart choreographer,
2006 Adelaide Theatre Festival 06
2007 Sydney Festival 07
2007 Adelaide
2007 Theatre de la Ville (Paris)
2007 Annecy (France)

2008 Video screenings – Mutamorphosis/Enter 3, Prague Czech Republik
2008 Video screenings - Art in Post-Biological Age, Modern Art Museum, Russia

Workshops

2011 Embodiment and Robots, **University of Applied Arts**, Vienna
2010 Machine Performers, **Cyberlabor**, Theaterhaus St-Polten, Austria
2009 Scenography and Media**, Bauhaus festival, Theaterhaus Jena**, Germany.
2008 Interaction Design, **Weimar-Bauhaus University,** Weimar
2008 Physical Computing, **National Centre of the Arts**, Mexico DF
2008 MoCap and Robotics, **CIANT**, Prague

Lectures

2014 The Blind Robot and Embodiment, Moscow Robo Show&Forum "Bal Robotov", Moscow.
2014 Embodiment, Touch and Perception, Aalborg University, Denmark
2014 Atmospheres as New Media Aesthetics, Singapore Art&Science Museum, Singapore.
2013 Spaces within space: experience design and atmospheres, **KSVET**, Slovenia.

2013 Machinic Atmospheres as Aesthetics, **KSVET**, Slovenia.
2013 Thousands years of Machine Performers, **Technarte**, Bilbao.
2012 Perception and Reception of Machine Performances, **Softcontrol**, Maribor.
2012 Robots on the Stage, Keynote, Synergia Workshop, **Tsinghua U**., Beijing, China.
2012 Robotics and Performing Arts: Reciprocal influences, Keynote, **ICRA 2012**, USA.
2011 Stage Robotics, **Ars Electronica 2011**, Linz.
2011 The *Tiller Girls*, **Belef 2011**, Museum Nikolai Tesla, Belgrade.
2011 Embodiment in Robotic Arts, Keynote, **ICRA 2011,** Shanghai.
2011 Art meets Soft Robotics, Keynote, **Swissnex**, Singapore.
2011 Area V5, **Science Gallery**, Dublin.
2011 Embodiment in Robotic Arts, **Contemporary Art Center WINZAVOD , Moscow.**
2011 Embodiment in Interactive and Robotic Arts, **University of Applied Arts,** Vienna.
2010 Embodiment in Robotic Arts, **ShanghAI Lectures,** Zurich.
2010 Two Thousands Years of Social Robotics, Keynote **ICSR2010**, Singapore.
2010 Embodiment in Interactive and Robotic Arts, **Northeastern University,** Boston.
2010 Machine Performers, **Bayreuth University,** Bayreuth.
2010 Physicality in Robotic and Interactive Art, **TASML**, Tsinghua University, Beijing.
2010 Anthropocentrism and the Staging of Robots, **Cyberlabor Symposium**, St-Polten
2010 Physicality in Interactive and Robotic Arts, **School of Culture Tech**, KAIST
2009 Scenography and Media**, Weimar-Bauhaus University,** Weimar
2009 Perception of Robotic Agents, **Thematic Correlations for Art Researchers**, Monash University
2008 Interaction Design, **Weimar-Bauhaus University,** Weimar
2008 Anthropocentrism and Staging Robots, **National Centre of the Arts**, Mexico DF
2008 Anthropocentrism and Staging Robots, **CIANT**, Prague
2008 Sensual Technologies, **Centre for Contemporary Arts** with Brunel U., London
2008 Robots in Entertainment, **Singapore Science Centre**
2007 Challenging Anthropocentrism, **Mutamorphosis**, Prague
2007 Interaction Design, **Academy of Media Arts and Design**, ChiangMai
2006 Motion Tracking for Media Control, **Lighting Dimensions Intl**., Las Vegas
2006 Mechanomorphic Machines for Performances, **VSUP / CIANT**, Prague
2006 Mechanomorphic Machines for Performances, **ZOOM** Brno
2006 Public artwork and RFID Technologies, **HCI 2006 Engage,** London
2006 Anthropocentricity and the Social Robot, **50th Artificial Intelligence Summit**, Switzerland.
2006 Collaborative process, In Artist's week of **Adelaide Theatre Festival**
2006 Sound Design, **R.M.I.T.** (Melbourne), Lecturer.

Prizes

LIFE 15.0 International Competition (2013),
Artificial Life Art competition, Honorary Mention for The Blind Robot, Telefonica (Madrid, Spain).

Prix Ars Electronica 2013 ORF, Ars Electronica (Linz, Austria),
Honourable Mention, Hybrid Arts for the Blind Robot.

Technarte 2013, (Bilbao, Spain), Best paper award.

Audi Art Ward 2010, (Dusseldorf, Germany),
Shared First Prize to Phillip Schulze for the *Tiller Girls*.

LIFE 12.0 International Competition (2009),
Artificial Life Art competition, Special Mention for *The Tiller Girls*, Telefonica (Madrid, Spain).

2007 Australian Cinematographer's Society National Awards
Commercials Retail – Highly Commended to Chris Herzfeld for *Devolution*

Australian Dance Award 2006 for Outstanding Performance by a Company (Sydney, Australia)

Ruby Awards 2006 (Adelaide. Australia**)** Innovation - Devolution

Helpmann Award 2006 (Sydney. Australia**)**
Best New Work - Devolution
Best Lighting Design – Devolution

Australian Cinematographer's Society (SA Branch Awards)
Commercials Retail - Gold to Chris Herzfeld (Devolution)
Corporate Productions - Gold to Chris Herzfeld (Devolution)

Conferences (organizer, reviewer, jury).

2011 Jury, National Junior Robotics Competition, Singapore
2011 Reviewer, Intl. Conf. on Social Robotics 2011
2011 Reviewer, Intl. Journal of Social Robotics
2010 International Conference on Social Robotics (ICSR2010), design competition jury

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Introduction

Premise

Research into the "Uncanny Valley", anthropomorphism, causality and animacy can shift human perception about the relationship between modalities and the abilities of machine performers on the stage and in other cultural environments. Furthermore by correlating and combining these issues, various concepts of embodiment can be compared and extended beyond current definitions found in robotics. These concepts range from the behavioural and performative to the holistic in nature. Within the framework of this thesis, I will attempt to design and produce machine performers that engage the audience's emotions by means of novel combinations of modalities with abilities, so that these performers can offer new insights in scientific as well as cultural environments.

Aims

The main aim of my research is to extend the concepts of current academic theories and investigations about the Uncanny Valley, artificial intelligence, the perception of motion, animacy, causality and artificial intelligence for other artists, theatre designers and directors. In order to do so, I attempt to define a number of specific theoretical objectives under each topic. For example in the Uncanny Valley, I hope to create a new approach about this controversy that comes from the perspective of experimental robotics and theatre. In the field of artificial intelligence, my aim is to combine and reapply current AI theories in order to create new models, so that the creators themselves can gain deeper creative experiences. Within this trajectory, I hope to raise awareness of the potentials of scientific and artistic correlations with regard to subjects within artificial intelligence like embodiment, by making more specific comparisons of the processes and the results.

Another set of aims relates to the concept of anthropomorphism. Here I hope to analyse and derive models about the role of mechanomorphism, zoomorphism and anthropomorphism in relation to *machine performer* in order to enhance the creative experience of such performers for future designers. This will require a careful analysis of the use of causality and animacy and the resultant audience reactions. Furthermore, by exploring current perceptual theories about combinations, reapplications, motion and causality I hope to shed light on new understandings of *machine performers* and their effect on the audience.

The final aim is to combine and correlate these theoretical discourses so that the premise of the dissertation is supported. However in order to do so, I have attempted to define a number of specific practical objectives in my research. These are:

- to gain insights about the development of robotic art agency so that the *machine performer* can become more appealing and engaging to viewers;
- to apply techniques of embodied artificial intelligence along with these results, and to develop machine characters with reference to neurobiological and psychological fields;
- to create more intensely empathetic experiences for audiences by giving my *machine characters* commonalities of embodied experience.

The results of such practical objectives are presented in this thesis and should be considered as an integral part of my research.

Methods and Methodology

This dissertation has been developed using a combination of art and science methods and methodologies, because I regard my research as needing both components of analysis. On the one hand, I regard the artwork I have developed during the course of this PhD as a set of case studies for the performing arts. On the other hand, I have examined relevant theoretical contexts through interview techniques, literature reviews and an analysis of AI projects.

Furthermore, I have attempted to create new methods and methodologies, for example, by transposing point-light animations from human motion control techniques onto machine performers, or by transposing psychological quantitative analysis from social robotics onto machine performers such as the Godspeed index. By following such new appropriations of scientific robotics onto machine performers I hope to show how valuable these new applications might be for generating deeper emotional response.

This thesis also attempts to contextualise the results my artworks, some of which are accompanied by a qualitative analysis of my experiments. The projects presented are *Devolution* (2006), *The Tiller Girls* (2010), *Area V5* (2009-10), *La Cour des Miracles* (2007, 2012) and *The Blind Robot* (2012). In *The Tiller Girls*, the discussion on embodiment becomes more pertinent, but still, quantitative analyses of two experiments on motion perception and animacy have been conducted. Discussions of both *Area V5* and *The Blind Robot* are accompanied by a quantitative analysis of audience perceptions of the work. In my first project in the PhD program, *Devolution*, I conducted audience discussions and interviews, plus an interview with the choreographer, and examined all the reviews from the critics.

The following is a table of some of the above methods and methodologies in greater detail:

METHODS (WHAT)	METHODOLOGIES (WHY and HOW)
1) Comparison of case studies: scientific and engineering projects with artistic and theatrical results	To contrast results from scientific and engineering domains with regard to artistic and theatrical results. Conducted by dialectical argumentation and critical analysis.
2) Interviews with people involved with machine performers	Collections of qualitative information about performance and case studies plus numerous ad hoc interviews after performances, during lectures and conferences.
3) Literature reviews	To survey and identify key concepts inside the lineage of robotic agents throughout history with the main focus on body representation, movement, context and theatrical constituents. To survey applicable theatre and performance theories and analyse theatre semiotics and the new field of embodied semiotics.
4) Current discourse investigations	– AI discourse, embodied cognition and its repercussions in the implementation of behaviour. – Psychological theories surrounding the perception of movement, animacy, causality, behaviour and emotion.

Table 1. Methods and Methodologies.

My aim is to correlate the above-mentioned findings, thereby constructing an alternative representation of machine performers, and to establish the basis of a theoretical framework for a new set of robotic characteristics. As mentioned earlier, one of these representations requires the transposition of point light displays from human motion tracking and the application of this method to machine performers. Point light displays often collect a time-based set of data by capturing individual key locations of the human body in motion. Instead of human bodies, I have utilized these motion capture systems as embedded in the *Tiller Girls* (see Chapter 4). In this case the qualitative and quantitative analysis I have collected was about the viewers' perceptive and emotional response towards motion (Blake and Shiffrar 2007). I have specifically investigated whether audiences can identify with the motion of the *Tiller Girls*.

I mentioned that I have used the technique of transposing scientific AI results (such as the principles found in the synthetic methodology from bottom-up AI) into four new artworks (*The Tiller Girls*, *La Cour de Miracles*, *The Blind Robot* and *Area V5*). The commonality of these works is that they attempt to empower the principles found in engineering and re-appropriate them into artworks. An important and controversial aspect of these case studies is their implementation of the realm of social robotics and the role of touch and gaze in the man-machine relationship.

Relation between Theory and Practice

I consider that these five case studies (i.e. the four just mentioned and *Devolution*) constitute at least 50 per cent of my research for the PhD dissertation, which is why I refer to them in each chapter. However, because quantification is seen as a very difficult form of analysis in the arts, where ambiguity and individual audience interpretation are highly valued, I have chosen to blend quantitative and qualitative forms of analysis. In the quantitative analysis of *Area V5*, *The Blind Robot* and the *Tiller Girls*, I borrow from previous experimental psychology protocols in order to draw potential comparisons with academic and engineering results. In *Devolution* I could take my results from the group of critics about impact of robots on the spectacle, or from the choreographer's point of view about the relations between size, scale and impact on the audience. In the *Tiller Girls*, certain members of the audience were interviewed about their levels of identification and the impact of a chorus of machine performers.

In designing the art experiments my main aim has been to trigger various visceral reactions about such concepts as movement and balance, or in the case of *Devolution* fear and horror. Because our cultural backgrounds can rarely be disconnected from our visceral reactions, I have also been interested in exploring these connections (Zimmer 2003). Therefore, I am also interested in how audiences reflect on an embodied level within a controlled environment like that created for *V5*. In this dissertation I hope to embed my own case studies in a new art and science context; this requires knowledge of the background of both contexts.

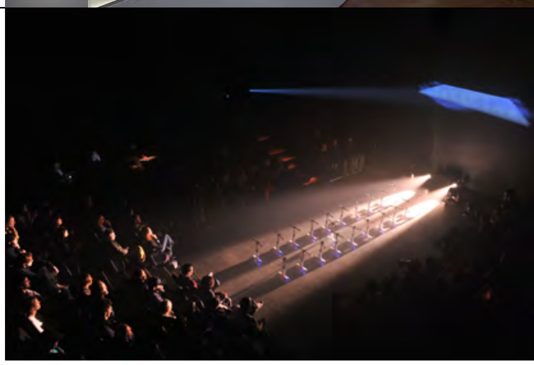
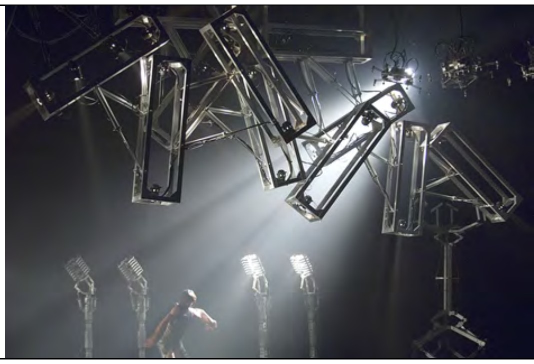
Practice		Description
La Cour des Miracles (1997, 2012)		*La Cour des Miracles* stages robot misery and pain. It comprises a series of heretical characters that are begging, convulsing, harassing, crawling and limping. It also incorporates a large-scale atmospheric environment that servers as a habitat for the characters.
The Blind Robot (2012)		*The Blind Robot* is a machine that has two anthropomorphic arms and hands. It touches visitors to make a mental image of what its fingertips have seen. It is a modern version of the Turk's Chess Player.
Area V5 (2009-2010)		*Area V5* is a large-scale environment. It comprises 60 mechatronic skulls that can follow the visitor. This work comments on the gaze in social robotics and the triggering of the Uncanny Valley.
The Tiller Girls (2010)		*The Tiller Girls* is a dance performance built upon Zurich's AI lab *Stumpy*. An ensemble of up to 32 identical autonomous robots is cast as a mechanical version of the early 20th century dance company of the same name. The piece is improvised and the robots' choreography, sound and visuals are performed live.
Devolution (2006)		*Devolution* is a dance performance with an ensemble of 10 human dancers and 30 machine performers. Devolution regroups six different families of robot. *Devolution* is a large-scale performance where robots span the performing space alongside human dancers.

Table 2. Summary of Practical Artwork

Overview of Research

I have examined the discourse surrounding embodiment by reading other people's theories about bottom-up AI: Pfeifer and Bongard (2007), Brooks (1999, 2002), Kaplan (2008); about embodiment: Csordas (1994), Johnson (2008), Gallagher (2012), Merleau-Ponty (1962); and about theatre: Fischer-Lichte (2008), Cormac Power (2008), Stanton Garner (1994). These theories are imbued with controversies about presence, definitions of performing, bottom-up versus top-down AI, embodied cognition and the role of mirror neurons. One of the most pertinent of these controversies is the Uncanny Valley and the discussion about cognitive dissonance (Kang 2009; Tondu and Bardou 2011). I also found research about the perception of human dance and mirror neurons in the performing arts (Hagendoorn 2004; Cross, Hamilton et al. 2006; Rubidge 2010). However, throughout this dissertation it is on the evolution of *machine performer*s that the primary focus lies.

The field of mirror neuron systems (MNS) is a flourishing one and, among the many hypotheses offered by MNS experts , neuroeasthetics and embodied simulation can help with the examination of audience perceptions of art and human performers. The framework of embodied simulation provides some background on how a phenomenological reaction arises in an observer of human movement (Gallese 2005). MNS proposes that embodied mechanisms can simulate actions, emotions and corporeal sensations. If, inspired by this scheme, I can relate mechanisms involved in the perception of human movements to the perception of *machine performers'* movements, I will be able to offer grounds for understanding the empathic reactions of audiences to inanimate objects.

The controversies surrounding the Uncanny Valley fuel the debate about the relevance of constructing humanoids. The humanoid-builder sees this Valley as a challenge and seeks instruments to measure the phenomenon (Ishiguro 2006; MacDorman and Ishiguro 2006), while the father of the Uncanny Valley himself proposed an "escape by design" towards less anthropomorphic machines. The Uncanny Valley formulation is highly problematic as it is bound to the quantitatively measured level of anthropomorphism in both human and machine, a clear violation of the qualitative characteristics of the scale's anchors (Ramey 2005). In investigating the

Uncanny Valley, I therefore look for the observer's perceptual grounds for rejection (or breach of credibility) of *machine performers*.

In performance theory, embodiment has become central to the analysis of audience perception and the reception of the human performer. For instance, in some non-representational theatrical performances, and certainly in dance, embodiment – and not the dramatic text – is the focus of the theatrical experience. This embodiment has to be experienced and empathized with by other bodies, those of the audience: "The synergy of the actor's embodiment and the spectator's willing imagination creates possibility, the potential for new understanding and insight charged by the necessity of intersubjectivity" (Fischer-Lichte 2008, p. 10). My task is to seek common ground between the perceived embodiment of human and machine performers. In doing so, I acknowledge that the phenomenological analysis of the machine performer also covers its interaction with the environment: it does not exist or act in isolation.

In Chapter One I attempt to reconstruct *the machine performer*, but in order to do so, I need to establish a historical trajectory based on the representation of the human body. The aim is to nuance the difference between animate and animated bodies, a characteristic used throughout the thesis to qualify *machine performers*. In the course of developing this trajectory, the dramaturgical, the thematic and the "performative" aspect of *machine performers* is examined. I compare current forms of representation found in robotics, particularly the social robot and the biologically inspired robot. These two forms are illustrated by analyses of two of my practical works: *La Cour de Miracles* and the *Blind Robot*. Both works develop narratives based on the enactment of a situation that reveals the misery of robots and their impairment (robot blindness).

In the course of my research about our identification with *machine performers*, I realized that a potential rejection of the robotic agent is associated with near human machines. **So Chapter Two** examines the Uncanny Valley. In it I address the controversies that this "Valley" raises within the robotic community and examine why and how "the uncanny" is more a problem in the academic than in the artistic world. This chapter attempts to reformulate the Uncanny Valley into a broader perspective: one that can be applied to non-anthropomorphic machines. This reformulation focuses on the breach of suspension of disbelief and the animate qualities of machine performers. I aim here to highlight the problematic factors of the Uncanny Valley and exemplify them by using a quantitative analysis of my own artwork (*Area V5*). But academic researchers may well be interested in my approach as a complement to their own.

So in **Chapter Three** I have expanded the notions of embodiment found in artificial intelligence and compared them with alternative views from fields such as phenomenology and anthropology. The constructed bodies of *machine performers* can offer dramaturgy as a way to understand how cultural convention is embodied and enacted. One aim here is to differentiate between the ecological body of the "robot in the lab" and an historical enactment of that body. These various levels of "embodiment" may enable us to better decode the roles of a functional machine seen within the AI context and a *performing machine* seen on the theatrical stage. In this context I present my three practical projects that investigate levels of embodiment and artificial intelligence principles. *The Tiller Girls* takes a robot developed to study morphological computing and locomotion and brings it onto the dance floor. Here I attempt to analyse how gender can be constructed and based on specific historical theatrical contexts so as to create culturally transformed results. In another project, *The Blind Robot* I reference the Turing test as a base for social embodiment, while in the characters of *La Cour des Miracles* I aim to show how to utilize techniques of artificial intelligence programming in order to produce bodily manifestations of pain. But what does an audience make of all this?

In **Chapter Four,** I look at *machine performers'* bodies from the outside and investigate various aspects of perception and the reception of machine performers. I explore concepts of animacy, causality and attribution found in moving objects. What is the impact of anthropomorphism on the perception of an alternative body? Why does such an alternative body need to introduce the audience to the differences between biological and mechanical perceptions of movement? It is here that I have concentrated on the types of *atmospheres* that are introduced to affect the perception and interpretation of group behaviours. For example what effects does "flocking" have on an audience? Here the stage presence of machine performers is analysed from a theatrical perspective, in order to determine if its performance lies between a sense of agency and a simple sense of automation. While *Tiller Girls* is utilized to primarily demonstrate the principles of attribution, it is also utilized to demonstrate a correspondence between the biological and mechanical perception of movement. Finally, in *Devolution* a major dance work with both human and machine performers, I endeavour to illustrate the various components of perception and reception introduced in this chapter

Framework: Presence and Embodiment

Embodiment and phenomenology offer me an interdisciplinary framework to conduct my analysis of the machine performer. This framework is reflected in the structure of the thesis. 1) The epistemology of the mechanical body through time serves as a basis to reconstruct the current and potential notions of the embodied machine performer. 2) By investigating cognitive dissonances found in machine performers (e.g. in the Uncanny Valley), I can look at expectations arising from embodiment (e.g. in an android) and the impact of theatricality on its reception. 3) By investigating potential ways to realign those dissonances, embodied artificial intelligence provides not only new ways of considering embodiment but also techniques and principles to achieve alternative morphologies that could have an impact on how artists can design machine performers. 4) From both the academic and artistic point of view the machine performer needs the co-presence of the audience to be fully realized. By looking at various aspects of the perception and reception of machine performers, from innate (biological) to constructed (intentional and anthropomorphic) motion, the loop can be closed on the definition of embodiment of the machine performer.

Threading through the thesis is the quest to pinpoint, and subsequently realize in practice, the qualities of the machine performer. As a starting distinction, there are two opposite qualities of machine performers: the animate and the animated body. An animate body has a flavour of aliveness while the animated one has a sensation of mechanical automatism. Analysed by historian Jessica Riskin, the famous *Kempelen Chess Player Automaton* (see Chapter 1) operated under the identification of two separate powers, the hidden "vis directrix" and the visible "vis motrix". Riskin reports historical writing by Windsich: "[he] celebrated Kempelen's accomplishment, not of an identity between intelligence and machine, but of a connection between intelligence on one side of the boundary and machine on the other" (Riskin 2003, p. 621). In other words, from the embodiment and the enactments emerged a sensation of body and soul congruence, an alignment of the vis motrix and the vis directrix.

This body and soul (in)congruence has been formulated for the contemporary world by many performance and theatre theorists through the concept of presence. The plethora of synonyms of presence in theatre are: immediacy, spontaneity, intimacy, liveness, energy, "the presence of the actor", etc. However, even if this sounds like common sense, i.e. qualities the machine performer should have, presence is a highly contested and vexed term, especially after post-structuralist critiques. Philosopher Jacques Derrida denies the reality of presence, in the sense of truth existing in itself, as a meta-logical foundation. Derrida points out that "every mental or phenomenal event is a product of difference, is defined by its relation to what it is not rather than by its essence" (Auslander 1995, p. 53)

But given the current visibility of presence and its central place in the phenomenon of performance, scholars have reified presence based on more nuanced discussions. Among these scholar are the main theorists I will be referring to: Fischer-Lichte (2008), Goodall (2008), Power (2008) and Garner (1994). Theatre theorist Cormac Power in the conclusion of his book *Presence in Play* eloquently refers to the artificial performer:

> At a time when concepts of presence are seen as problematic, when notions of perception and subjectivity are being (re)addressed in terms of how experience is never 'pure' but always encoded within cultural inter-texts, theatre's ability to complicate the experience of the present seems especially relevant. Indeed, theatre's manipulation of presence can be seen as a crucial asset at a time when technologically produced representations are increasingly capable of concealing the artificiality of their construction. (Power 2008, p. 198)

Further on, Power then reaffirms that presence is an unstable experience (or multi-stable as expressed by Fischer-Lichte) and he sees presence as a function of signification:

> One of the challenges left to us by theories of phenomenology and poststructuralism is that of appreciating theatre as a representational form that explores the intricacies of presence in particular ways, as we move away from merely privileging theatre as an essentially 'present' phenomenon. The spatial and temporal parameters of theatrical performance, far from housing a secure and stable 'present' experience, should instead be seen as places of almost infinite possibility in which presence is subjected to playful manipulation. (Power 2008, p. 205)

Power develops his concept of presence over three main modes: making present (the fictional mode of presence), having presence (the auratic mode of presence) and being present (the literal mode of presence). He derives these presences from Garner's presencing. "Instead of presence, the theatre asks to be approached in terms of presencing; theatrical phenomena are multiply embodied, evoked in a wide variety of experiential registers, refracted through different (and sometimes divergent) phenomenal lenses" (Garner 1994, p. 43) Power claims that "the notion of presence, reconfigured through phenomenological investigation into 'presencing', provides a more dynamic and less essentialising perspective"(Power 2008, p. 191) .

By looking at presence as a play of actualities, I can link phenomenology with presence, two main issues in this thesis. *Presence* and *presencing* refer to the multiple facets of the embodiment of the machine performer, the qualities of its co-presence with the audience and its fundamental double vision (or intrinsically multiple ontological status).

Presence is also found as a term in virtual reality and human-robot interaction (HRI). Virtual reality and HRI both seek a sense of presence in the actuality of events – within the artificiality of their apparatus. Presence in this case is more related to the qualities that make the "illusion" credible, giving the user an appearance of being present in virtual space.

Framework: The Machine Performer

When I bring theatre into the discussion of this thesis, I deal more with the theatricality (or dramatization) of the spatio-temporal experience between the audience and the machine performer. These encounters include theatre, dance, human-robot interactions as well as interactive robotic artworks. This spatio-temporal encounter implies the intrinsic characteristic of co-presence between the audience (in the broad sense) and the performer (on stage and in other contexts).

I do not seek to compare machine performers with actors rendering a dramatic text on stage, though I might make small incursions into performance theory. As this field is humanocentric, I aim to transpose some of those theories towards application to machine performers. I have coined the term 'machine performers' to express the aspect of my work as being based not directly on a dramatic text but rather on the behaviour of fictional characters, using sound rather than voice. This expression deliberately enlarges the notion of acting (theatre) to include dancing and movement, performance art, kinetic art and the robotic sense of "performing" a task or a goal.

Accordingly, I will not fully embark on the analysis of audience reception of (or participation in) a specific work, but rather dissect elements of perception and reception to bootstrap the process of understanding the act of perceiving the machine performer.

I employ the word machine as opposed to robot to include a broader definition of the machine as a performing agent. I define the machine performer as embodied and intentional (whether or not this is apparent) and set to perform in a specific spatio-temporal situation (e.g. a play, a social or cultural context). The term robot has many connotations in its visual representations: android, industrial arm, automaton, to name only a few. The vagueness of the word machine helps me to present non-anthropomorphic embodiments as "equal" to anthropomorphic ones and to look at machine functions (behaviours) in a broader context (from the mechanical to the human).

Conclusion of the Introduction

My analysis has left me with many questions, but certain attributes of machine performers are still obvious. The *machine performer* has to be animate in order to be accepted by an audience. These audiences seem to be able to relate and identify with alternative morphologies for *machine performers*, and I will attempt to demonstrate this claim with my analysis in this thesis. I will use some of my own experiments to prove that a correspondence between a robot and a human body may change and be affected by the attribution of intention during animacy experiments (*Tiller Girls*). Also the attribution of character to a machine performer may end up severely modulating audience perceptions. Based on both quantitative results (*The Blind Robot*) and qualitative analysis (*The Tiller Girls*), I hope to offer new approaches to the building and designing of machine performers for the stage, to the shifting of atmospheres so as to enhance the perception of machine performers, and finally to offer scientists different ways of thinking about the "Uncanny Valley" as a valid aesthetic choice for audiences. The following table illustrates my own attempts, inspirations and reactions to building such performers:

Practice Name of Machine Performer	**Reconstructing the Machine Performer**	**The Uncertain Valley**	**Comparing Embodiments**	**Perception and Reception**
La Cour des Miracles	Aligned to bio-mimicry Historical context Staging Embodiment		Implementation of subsumption architecture for behaviours Morphological computing	Anthropomorphism Animacy, causality and attribution Atmospheres
The Blind Robot	Aligned to social robotics Shifting from behaviours to experiential for the audience		Quantitative analysis of the perception of two “characters” played by the Blind Robot Reformulation of a Turing test	Experiential
Area V5		Pastiche of Uncanny Valley archetypes: death, fear Quantitative Analysis		Scenography makes atmospheres
The Tiller Girls			Qualitative description of the development process of the work, the comparison between AI robots and machine performers and comparison between machine performers and human performers	Heider-Simmel quantitative analysis of perceived animacy Quantitative analysis of point light displays reaction Body schema and correspondence
Devolution				Anthropomorphism Atmospheres from populations of identical bodies Body schema and correspondence Staging the “unreal”: swarms and unclear attributions to machine performers

Table 3. Practical artwork and relation to chapter topics

As far as I know there has been little research about these shifts in human perception of *machine performers* on the stage from both an academic and an artistic perspective. It is hoped that other researchers, as well artistic stage designers, will continue to explore these behavioural, performative and holistic approaches, so that *machine performers* may have the chance to star more often in cultural environments.

1
Reconstructing the machine performer

1.1. Outline of Chapter

The history of robotic art is situated in the long evolution of representations, models and simulations of the living body by mechanical objects. It is driven by an ongoing inquiry into the comprehension of the human environment (nature), behaviours and genesis. For although machines are universally regarded as different entities from us, they can nevertheless serve as a tool for understanding the human within the structure of the world (Demarinis 1990).

It is significant in this respect that robots and robot-like machines typically exploit theatrical means (Sussman 1999; Gorman 2001). According to historian Jessica Riskin, the evolving boundary between simulation and representation found in automatons since the 18th century is the ongoing essence of what she considers artificial life[1] (Riskin 2003). In performance theory, a similar tension is found between the performer as representation and as an embodied agent (Fischer-Lichte 2008). By re-examining the history of machines and robots from the slanted perspectives of human body representation and theatricality, as well as (blurred and multiple) man-machine relations, my aim is to reconstruct the *machine performer* within the historical landscape leading up to and including the present.

Via a genealogy of mechanical-artistic renderings I will first establish that machine mimesis corresponds in the West to each era's understanding of the human body, society and nature. Secondly, I will trace dramaturgical, thaumaturgical and performative ingredients found in the presentation of robots in order to augment the viewer's reception of the *machine performer*. Thirdly, I will expand on the performative aspects of the human representations found in automatons, androids and robots over the last three centuries, at a time when the definition of life was (and still is) constantly and ambiguously shifting.

To conclude this history, I will explore how authenticity, verisimilitude, mimicry and representation can shift audience perceptions of *machine performers*. I will compare two current forms of representation in robotics – the social robot and the biologically inspired robot – to illustrate their influence on the construction of *machine performers*. These two forms both embrace and breach the cybernetic model of the robot, and their comparison will establish a rationale and context to further explore the Uncanny Valley and artificial intelligence in the next two chapters respectively.

I will illustrate the chapter's analyses with two practical works: *La Cour des Miracles* (1997-2012) and *The Blind Robot* (2012). Referring to historical moments and artefacts, both works establish a frame of presentation for *machine performers*. Furthermore, both works walk the thin line of simulation vs. representation, as both embody improbable situations for animated metal structures, namely pain and blindness.

1I follow Riskin's definition of artificial life as any attempt to understand living processes by using machinery to simulate them. Fischer-Lichte, E. (2008). The Transformative Power of Performance: A New aesthetics, Routledge..

In the process of reconstructing the *machine performer*, I will look at the illusion of life – or more specifically, the illusion of performing that can be found (or not) in a mechanical object on stage. In other words this chapter is concerned with the characteristics of the *machine performer*'s agency throughout history.

The fascination of movement as a sign of life includes in itself a concern about the location of life. Media theorist Jacqueline Stacey and anthropologist Lucy Suchman address the question whether this location is antecedent, integral or consequent to that which moves. In their analysis of the confluence of animation and automation they state:

> We might distinguish between bodies and things, the organic and the inorganic, not as animate or inanimate but rather as animate or animated. That is, we take the former to embody, inherent in their nature, processes of contingent and generative transformation, while the latter require something outside themselves, an external force, to set them in motion. (Stacey and Suchman 2012, p. 17)

Throughout the chapter I will return to this animate-animated disjunction as a common framework to examine the multiple facets of the history of the mechanical reproduction of life. Having established various qualities and characteristics of this equation via different historical trajectories based on the presentation, representation and misrepresentation of the human body, I will finally develop a trans-disciplinary perspective of robotic agency and embodiment for the *machine performer*.

Before doing so, however, I will show in the following section that the shift from cybernetics (1960s) to phenomenology (1980s and on) that caused the appearance of hybrid *machine performers* also generated a controversial discussion about the dualism of mind and body.

1.2. The Robot: an episteme of the human body

Robotic art has broad roots and a rich cultural history. This history embraces modern science-fiction as much as artificial creatures (either real or imaginary); from ancient artificial maidservants to medieval golems to the homunculus of the Renaissance and the androids of the Enlightenment. The western history of the human machine, more than two millennia old, is driven by the ongoing quest for deeper understanding of the true nature and genesis of the inner self in the environment.

In *Sublime Dreams of the Living Machines*, historian Minsoon Kang argues that the automaton is a central idea of the Western imagination: "In […] Western thought, it has functioned as a kind of conceptual chameleon, embodying greatly varying sets of ideas and attitudes from one period to the next" (Kang 2011, p. 5).

1.2.1. Non-anthropocentric shift

The media theorist David Tomas writes about modifications of the human-machine relationship as a "machine-based history of [the] western body" (Tomas 1995). Tomas often refers to cybernetics discourse, particularly to Norbert Wiener's writing on the history of mirroring the human body with machines. Wiener traced the parallel histories of machines and human bodies when he presented a history of automata divided into four stages that generated four models of the human body (Wiener 1948): firstly, a mythic golemic age that referred to the body as a malleable, magical, clay figure; secondly, the age of clocks (17th and 18th centuries), when the body was seen as a clockwork mechanism; thirdly, the age of steam (19th century), which transferred the body into a Cartesian scenario, a "glorified heat engine" that burned combustible fuel instead of glycerine from human muscles; finally the fourth and last stage, which Wiener identified as the age of communication and control (the age of cybernetics), an age marked by a shift from power engineering to information and communications engineering, from an "economy of energy" to one based on "the accurate reproduction of signals" that understand the body as an electronic system.

After Alan Turing's pioneering work, robotic art and artificial intelligence emerged from the assumptions established by cybernetics. The appearance of robotic art in mid 1960s cybernetic discourse is connected with an anti-mimetic shift in the history of humanlike machines.[2] This shift brings a cancellation of borders between the fields of art and reality (artefact and nature), between mimesis, representation, and life itself. Of the landmark works of this era, *The Senster* (1969-1970) by Edward Ihnatowitcz is an instance of autonomous behaviour in art (Kac 1997). *The Senster* was a behaviour-based (and biologically inspired) articulated body that tracked and leaned towards human spectators. As Tomas argues:

2 Burnham described it as a history of both figurative sculpture – in accordance with the mechanistic automatons of the 17th century – and robotic sculpture. He concludes that: "Suddenly, art history naturally assimilates history of life creation as well as an evolution of machine." Riskin, J. (2003). "The defecating duck, or, the ambiguous origins of artificial life." Critical Inquiry **29**(4): 599-633.

> The cybernetic automaton's mirroring of the human body was not established on the basis of conventional mimicry, as in the case of androids and their internal parts, so much as on a common understanding of the similarities that existed between the control mechanisms and communicational organizations of machine systems and living organisms. (Tomas 1995).

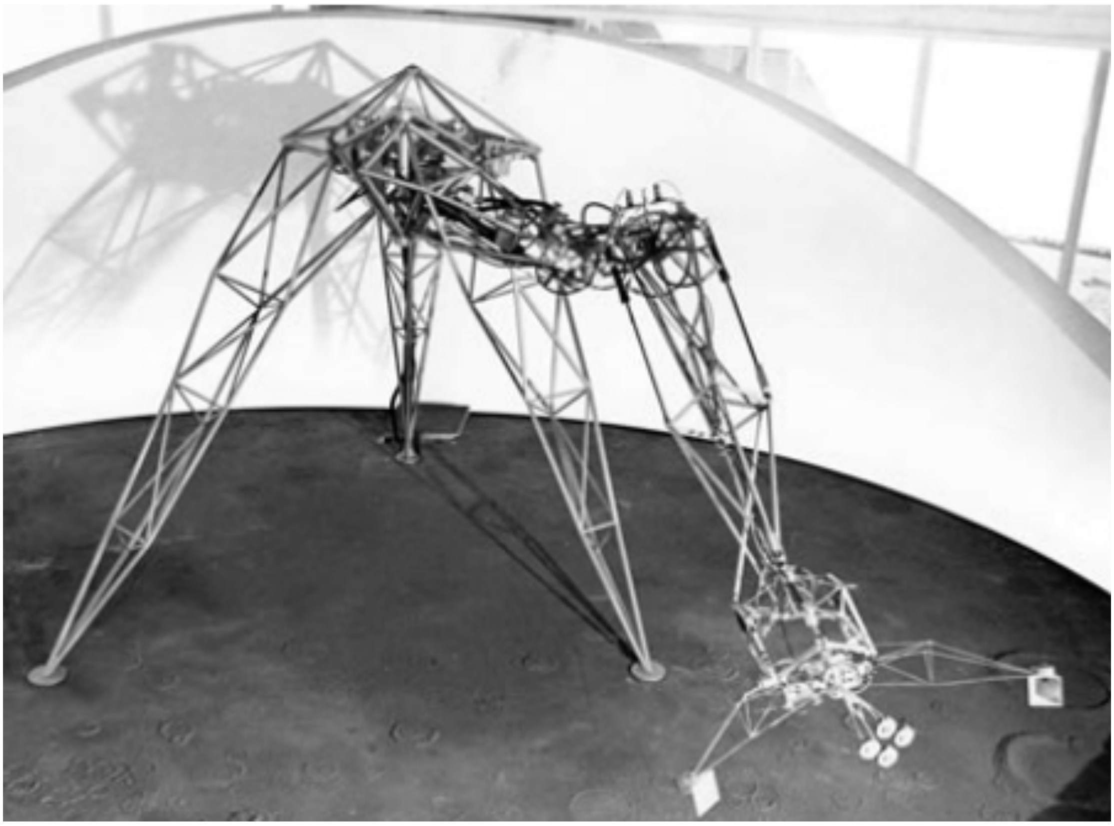


Figure 1. *The Senster* by E. Ihnatowitcz (version from 1970)
Permission to reproduce this image has been granted by Richard Ihnatowitcz.

The anti-mimetic cybernetic shift in robotic art illustrated by the *Senster* brought a new aesthetic dimension that preferred behavioural modelling to representational form, and motion to the mimesis of static objects.

Unfortunately, Tomas' analysis stops in the era of cybernetics (1960s) and does not include recent representations of robots. He does, however, offer a good analysis of the lineage of machines as signs of the understanding of the western human body. But to consider cybernetics as the current model of a robotics view of the human body poses many problems.

Robotic artist and theorist Simon Penny places cybernetics in opposition to digital computation (Penny 2012; Penny 2012). For Penny, cybernetics offers bottom-up situated agents that break free from anthropocentrism; it was what he calls "digital computation" that was dualistic and aligned with the symbolic computation of 1960s artificial intelligence. Nevertheless, despite Penny's eulogy of cybernetics, this field is strongly slanted to symbolic processing and cognition, to intelligence rather than embodiment. Even if cybernetics has feedback and is contextually situated, its essence is about representation via signal and information. As a system of signals modelling the biological, cybernetics does not necessarily entail a phenomenological body. Thus computer scientists and roboticists Noel Sharkey and Tom Ziemke clearly define mechanistic and phenomenal embodiment models for the robot (Sharkey and Ziemke 2001), stating boldly that a mechanistic embodiment is a control architecture of sensors and effectors and nothing else.

I would, then, suggest referring back to cybernetics and post-cybernetics for an understanding of more recent developments in robotics, as both models utilize feedback and situated bodies. I would bring the nuance of having cybernetics more aligned with a dualistic Cartesian model of the brain and the body, where the symbolic computation of sensor signals happens in the "processor". I would then look at post-cybernetics as aligned with post 1980s notions of artificial intelligence (nouvelle AI), where signals and information are difficult to situate and model and the border between the brain and the body blurs. A more comprehensive analysis of the impact of cybernetics in the 20th and 21st centuries will be presented in section 1.4.

1.2.2. Artificial and natural

The paradox of the robot can be found in the ambiguous status of artificial human-like creatures (androids) and their existence. This paradox is not only present in the case of fictitious artificial creatures but also in the case of the 'real' mechanical puppet or android.

The evolutionary drive to mastery of the environment has repeatedly issued in the dream to create an artificial human being and the need to create helpers for us. On the one hand, this is seen as an attempt to imitate a 'Creator', to make a creature in our own image, or even to discover the secret of life. On the other hand, it may be an entirely practical ambition to make the perfect servant. This second motive is often connected with utopian projections of an ideally ordered social system. Aristotle in his fundamental work *Politics* wrote:

> For if every instrument could accomplish its own work, obeying or anticipating the will of others, like the statue of Daedalus, or the tripods of Hephaestus, which, says the poet, 'of their own accord entered the assembly of the Gods'; if, in like manner, the shuttle would weave and the plectrum touch the lyre without a hand to guide them, chief workmen would not want servants, nor masters slaves. (McKeon 2009)

Roboticist Frederic Kaplan visits the history of Western myths and novels from the perspective of the human "creation act" (Kaplan 2004). Kaplan traces the development of Western machines by looking into the artificial versus the natural. At an early stage the artificial reproduction of nature is seen as a positive act (homage to the gods): it is a twofold quest with the creation of the artificial companion (Pygmalion) on one hand and the understanding of the secret of life (golem/homunculus) on the other. Further on in time, Kaplan opposes the Enlightenment, with its separation of the natural from the artificial, to Romanticism, which elevates the natural above the artificial. Finally, his analysis brings the reader back to the religious dimension of creativity, where artificial reproduction is seen as an offence against God. In this case, the human creator becomes a "Sorcerer's Apprentice" – either a mad lover (Future Eve, Sandman) or a mad scientist (Frankenstein).

Kaplan's purpose is to compare Western and Japanese cultural attitudes to the displacement of the human from the central equation by robots and artificial creatures:

> Several cultural elements suggest that in the Western world, machines are very important for understanding what we are. We think of ourselves by analogy with the way machines work. But at the same time, technological progress challenges our specificity. That is why we can at the same time be fascinated and afraid when confronted with new machines. In Japan, in contrast, machines do not seem to affect human specificity. The difference between the natural and the artificial is not so crucial and building machines is a positive activity in the search of the natural laws that govern the world. (Kaplan 2004, p. 12)

Finally Kaplan turns the artificial-natural equation back to the human:

> Peter Sloterdijk has examined closely the mechanism that we use to prevent machines from upsetting us. He explains how machines challenge our "narcissistic shields" and how we painfully resist in this fight. But in the end, the new metaphors of humans introduced by new machines inevitably win, forcing the Western man to redefine himself. (p.14)

Likewise, Riskin investigates how the automaton represented the problem of where the machine ends and the animal begins:

> The attempt to reproduce life in machinery, in tandem with the attempt to find where mechanical reproduction would fail, has resulted in an ongoing taxonomic exercise, sorting the animate from the inanimate, the organic from the mechanical, the intelligent from the rote, with each category crucially defined, as in any taxonomy, by what is excluded from it. (Riskin 2003, p. 613)

In his controversial book *Man-Machine* (1747), Julien Jean Offray de La Mettrie proposed that not only the body but also the mind was of material origins. De la Mettrie put forward the metaphor of the human being as a machine (with Descartes, the metaphor concerned animals) and not the other way around. La Metttrie's thesis starts from considering the continuity of biological function and bodily structure in living things (Franchi and Güzeldere 2005).

De la Mettrie was one of the first to suggest that there was no clear distinction between living and dead matter – an approach that was both modern and contentious. However, his rejection of Cartesian dualism was far too reductive, and in this respect similar to the equivalent modern cybernetics model. Both models tend to claim that the human being is a machine. However, while de la Mettrie saw the human being as a mechanical construction on the Western model, cybernetics portrays the human machine as a dedicated symbolic processor.

Kaplan expands Tomas' lineage by comparing Western and Japanese views of the machine. His historical description, centred on the creator of the machine, is more psychological than Tomas' and has expanded inventors' notions of the Western body. However, the current development of machines in Asia has many pitfalls. Japanese researchers tend to be strictly positive and not critical enough of their own developments, particularly in relation to *machine performers*. This applies above all to the deeper psychological perspective of the machine and its personification.

Kaplan, via Sloterdijk, extends this psychological perspective when he takes up Tomas' analysis of the western body and combines these with narcissism. However I consider defining human identity through machines to be far too narrow an analysis, because the perception of a machine always extends beyond its shape and form. In my own artwork, I have attempted to move beyond these anthropocentric views of the machine and their contextual and psychological presence on the stage.

1.2.3. Animate-animated

As the borders of what one considers animal or machine shift through the constant evolution of the understanding of the human body, the perception of a mechanical artefact as either animate or animated will also evolve. Revisiting Tomas' chronology of the western body, one can observe that an 18th century automaton would have been considered almost a living animate creature. Nowadays, however, it would certainly be considered mechanical: simply an animated object. Table 4 presents my résumé of the animate-animated qualities of the machines discussed in this section.

Animate	**Animated**
Tomas/Wiener western body. Mythic golem, Age of Steam.	Tomas/Wiener western body. Clockwork, cybernetics.
Post-cybernetics. Phenomenological embodiment.	Cybernetic symbolic processor acts as animator of sensorimotor body. Mechanistic embodiment.
The Senster. A behaviour-based machine appears animate.	*The Senster*. If audience considers interaction as simple feedback, behaviour becomes too literal and borders on automation.
Given "life", creatures appear autonomous, even sometimes rebelling against their creator: Golem, homunculus, Pygmalion, Frankenstein, Eve.	Artificial Creatures are initially made, conjured, vivified by the creator, acting as the initial animator.
De la Mettrie proposed a union of mind and body, both contributing to animation.	In a dualist mind-body scheme, the mind does the animation of the body.
Natural Animals are animate.	Artificial Objects that appear animated labelled artificial.

Table 4. Animate and animated, natural and artificial

The anti-mimetic shifts emanating from cybernetics do not fully represent trends in robotics in the late 20th century. In what follows, I will, therefore, look more closely at the history of discourse about the mind-body relation. In phenomenology, for example, the body is always considered to be an integral part of both space and context, i.e. of the continuum ranging from the physical to the cultural environment. An analysis of the manipulation of this context by tricks of dramaturgy and mise-en-scène in magical machines, automatons and androids will serve as a measure of the ongoing spiral of changes in mind-body discourse.

1.3. Magical machines, automatons and androids: the theatre of lures

It is significant that the act of presenting the machine often invokes theatrical means: a judicious mise-en-scène found in Cellini's sculpture, thaumaturgical lures employed in the *Chess Player*, an improbable defecating duck by Vaucanson, androids cast as child characters by Jacquet-Droz, and nowadays the role of media in framing (hiding, cut in editing), and with it the functional pitfalls of state-of-the-art robots.

For the purpose of this section, theatrical means, staging or mise-en-scène can be seen as set-ups that focus on some things while obscuring others, forms of narrative that direct the attention of the audience, or sequenced events framed and connected via cause and effect. The decoy or lure is the pivotal point in staging these artefacts. The ambiguous status of the artificial 'human' or 'natural' object, more mystified than explained, becomes the dramaturgical element itself.

1.3.1. Lures of the past

In *The Lure of Antiquity and the Cult of the Machine*, Horst Bredekamp opens by telling a story about the Italian sculptor Cellini. Bredekamp relates how in order to survive a difficult vernissage of an incomplete artwork, Cellini had the idea of bringing a spark of life into his sculptures. The trick was to incorporate mechanical levers in their bases, so that people hiding behind could subtly set the sculptures in motion. As the presentation was at dusk, Cellini could not only hide the obviously human intervention but also augment and blur the perception of his figures' movements (Bredekamp 1995).

Thaumaturgical strategies can be found in Kircher's "miracle machines", comprised of miniature, artificial universes bearing encrypted messages from a playful creator. In *Between the Demonic and the Miraculous*, Gorman argues that the machines of the Kircherian museum (curiosity cabinets) were more than mere mechanical demonstrations, and that it was clear for Kircher (1602-1680) and his immediate entourage that these machines were, in some real sense, magical. Kircher described his machines as "various, curious and exotic spectacles of admirable effects, wonders of recondite inventions, that are rightly called magic, free from all imposture and suspicion of the forbidden Art" (Gorman 2001). Gorman considers that Kircher's machines derived from a culture of special effects, where only an elite social group was initiated into the basis of the enigma. Likewise, performance and puppet theorist Mark Sussman writes that thaumaturgical strategies often intensified the swindle found in public robot performances (Sussman 1999). Sussman begins with the tension between the magical and the technological: "Certain pre-technological performances […] can give us some insight into the tense metaphoric operations and interconnections of faith and scepticism, or belief and disbelief, in the staging of new technologies […]" (p. 82).

In his analysis of the staging of the *Chess Player* automaton by Wolfgang von Kempelen (1762), Sussman sees the paradox of the machine as an explicit technique for generating audience tension:

> The Chess Player highlights the crucial role of the observer's simultaneous belief and skepticism in evaluating the object on display, presenting a limit-case in the development of a theatre of machines: part puppet show, part scientific demonstration, part conjuring trick. (p. 92)

He suggests that the transmission of human intelligence into an inanimate body extends the context of android/automaton staging in general, for it both demystifies and re-enchants the performing object itself:

> The automatic thinking machine that concealed, in reality, a human person, can be seen as a model for how a spectator might reify, and deify, the hidden power at work in a new form of intelligent machinery. (p. 94)

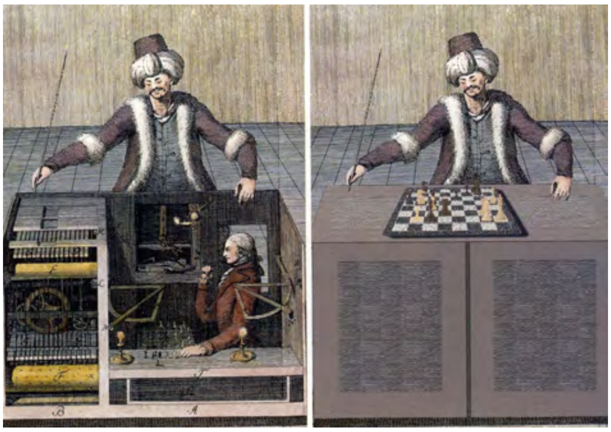


Figure 2. The *Chess Player* (Sussman 1999)
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Figure 3. The Chess Player (Sussman 1999)
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From the Renaissance to the late 19th century, automatons entertained audiences, and their ambiguous existence was enhanced not only by the way they were staged, but also by their appearance and character. Androids/automata are often connected with the effort of their designers to show their own (human) competence and workmanship. The Swiss fine engineers and clockmakers, father and son Pierre and Henri Louis Jacquet-Droz (1721-1790, 1752-1791) constructed *The Writer*, *The Draftsman* and *The Musician* (a lady playing the piano). Arguably Jacquet-Droz might have programmed his writer-automaton to engrave the sentence "Cogito ergo sum" as a play on Descartes' contemporary theories. Nonetheless, his android was deliberately staged as undecidable (neither true nor false) – the status of an artificial being.

Gaby Wood observes that in the Age of Enlightenment, androids/automata were frequently designed in the image of children: "some inventors intended their objects to be artificial forms of an eighteenth-century ideal – the child as a blank slate, the purest being" (Wood 2002). The android's childlike appearance functioned as a sign of perfection (innocent beings) and a suggestion of the automaton's ability to learn, as well as a trick that could changed the audience's attitude towards (possible) failure of the automatons: "their creators wanted them to look young so that the mistakes resulting from their early efforts (as prototypes) would be forgiven" (Wood 2002). Moreover, Jacquet-Droz's barefoot writing automaton, with its schoolboy appearance, represents the conviction of the period that children would learn more freely if unhampered by shoes.

The ontological status of these automatons was camouflaged[3] and interpreted as an ambiguous fluctuation between the mechanical and the organic, the animate and inanimate. Its reception was correspondingly chequered. "When Pierre Jacquet-Droz exhibited his writing automaton in Spain, he was accused of heresy; both the man and the machine were imprisoned for a time by the Spanish Inquisition"(Wood 2002). A journalist who experienced a performance of the *Musical Lady* reports acceptance of the android's living status. It was advertised on posters as a "vestal virgin with a heart of steel", but the journalist's impression was different: "she is apparently agitated with an anxiety and diffidence not always felt in real life" (Wood 2002). The android seemed to him more alive than is commonly the case in life itself .

Figure 4. *The Musical Lady* (Jacquet-Droz)
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The *Canard Digérateur* was an automaton in the form of a duck, created by Jacques de Vaucanson in 1739. This duck was part of a larger performance comprised of a flute and a drum player. The mechanical duck appeared to have the ability to eat kernels of grain, and to metabolize and defecate them. But the duck did not actually have the ability to do this – the food was collected in an inner container and the pre-stored faeces were 'produced' from a second, so that no actual digestion took place.

3 Wood cites examples of androids that bled 'real' blood or were covered with 'real' skin. Burnham, J. (1968). Beyond Modern Sculpture: the effects of science and technlogy on the sculpture of this century. New York, Georg Braziller..

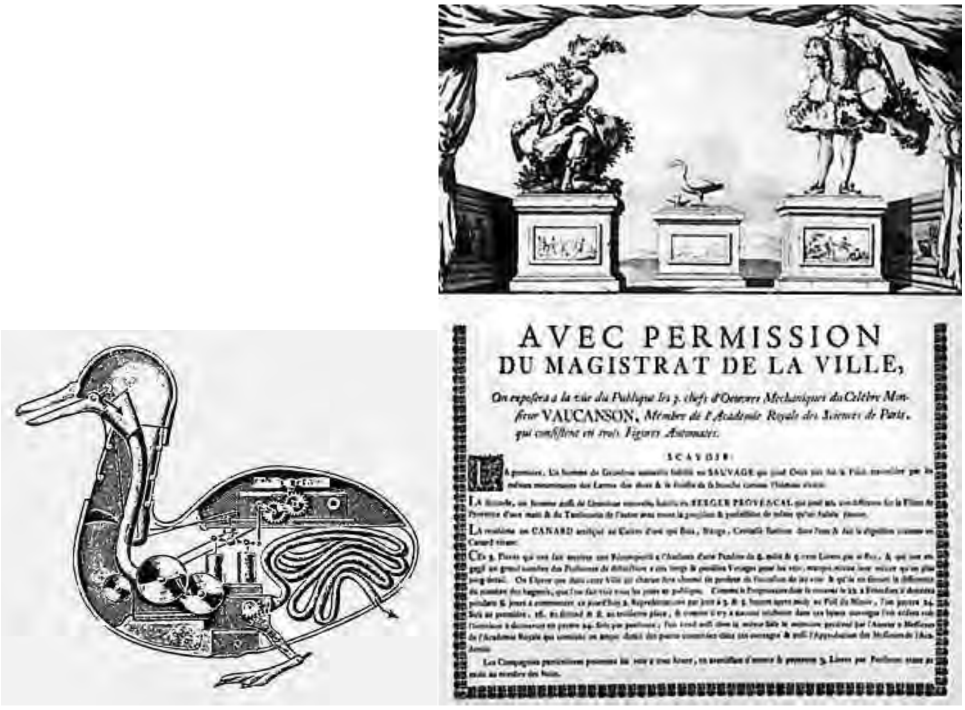

Figure 5. Vaucanson's *Canard Digérateur (Vaucanson 1739)*
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According to Jessica Riskin,

> Vaucanson's automata were philosophical experiments, attempts to discern which aspects of living creatures could be reproduced in machinery, and to what degree, and what such reproductions might reveal about their natural subjects. Of course, his automata were also commercial ventures intended to entertain and demonstrate mechanical ingenuity. But their value as amusements lay principally in their dramatization of a philosophical problem that preoccupied audiences of workers, philosophers, and kings: the problem of whether human and animal functions were essentially mechanical. (Riskin 2003, p. 601)

Shifting forward in time to the late 20th century, Belgian artist Wim Delvoe's *Cloaca* is an actual biological reconstruction of a human digestive system. Delvoe's machine replicates functionality (the excrement was tested as human) but not scale, as Delvoe requires an entire room to replicate what happens in our bodies. *Cloaca* is a large assembly of bio-reactors, a "Rube-Golberg" machine that can actually generate human excrement from the food "ingested". Delvoe does not hide any of the digestive steps, and the presentation of the object is almost didactic, though at the same time it maintains an aura of mystification emanating from people's obscure and sensitive understanding of their own bodies and their scepticism about the possibility of any faithful disembodied reproduction of bodily functions.

Figure 6. William Delveo's *Cloaca*
Permission to reproduce this image has been granted by the artist.

In 1898, to the amazement of thousands of people, the Serbian inventor Nikolai Tesla (1856-1943) demonstrated a remote controlled submersible boat. Tesla was known for his showmanship and upon instructions given by the crowd (a common audience interaction for magic tricks), the boat would turn, submerge and so forth. For Tesla, the machine embodied the mind of the distant operator. Tesla would describe this automaton as having a "borrowed mind". His writings refer to the development of machines with their own mind as a follow-up to this experiment (Rosheim 1994).

1.3.2. Lures of the present

The machine is a mythical construct. In the *Book of Electronic Arts*, Mulder and Post continue sociologist Lewis Mumford's insights found in the *Myth of the Machine* (Mumford 1967):

> A machine is not only a complex tool; it is always also a social device. It consists not only of material parts but also of immaterial elements, a mentality, a belief in a purpose or an effect, for instance in progress or in the inevitability and irreversibility of technological developments. (Mulder, Post et al. 2000, p. 18)

Jutta Weber further criticizes this "belief in a purpose" when she analyses the video documentation of current robotic work, namely social robotics. She points out a discrepancy in the truth discourse of this scientific and engineering field, between the authenticity and the presentation of the artefacts:

> Another important factor here is that media such as video or simulation opens up opportunities for implementing the fake of sociability into the human-robot interaction and thereby to compensate the malfunctioning machines and to veil the simple-mindedness of still many artefacts. (Weber 2007)

When Lucy Suchman reports her encounter with MIT's much mediatised robots Cog and Kismet, it becomes clear that the presentation of these agents is staged, but this staging surrounds the actual capabilities of the robot with mystery. First, the recording of events reframes the perception of the robot's body while maintaining an aura of its current and future agencies:

> Like other conventional documentary productions, these representations are framed and narrated in ways that instruct the viewer in what to see. Sitting between the documentary film and the genre of the system demonstration or 'demo', the videos create a record that can be reliably repeated and reviewed. These re-enactments thereby imply that the capacities they record have an ongoing existence; that they are themselves robust and repeatable, and that like any other living creature Cog and Kismet's agencies are continuing to develop and unfold. (Suchman 2006; Suchman 2007)

Second, Suchman's actual encounters with Kismet did demystify the robot Cog. Those encounters were in "off-stage" and "on-stage" situations, the former relegating the agent to the level of a prop waiting to be brought onstage, the latter creating a "live" unedited interaction with Cog. Backstage, Cog's body remainder, not visible in media portrayals, impresses Suchman; she is struck by the amount of human labour and affiliated technologies that are required to give Cog its agency. Onstage, Suchman could not elicit any coherent or intelligible behaviour from Kismet:

> The contrast between my own encounter with Kismet and that recorded on the demonstration videos makes clear the ways in which Kismet's affect is an effect not simply of the device itself, but of Breazeal's trained reading of Kismet's actions and her extended history of labors with the machine. In the absence of Breazeal, correspondingly, Kismet's apparent randomness attests to the robot's reliance on the performative capabilities of its very particular 'human caregiver'. Like all forms of agency, in other words, Cog and Kismet's capacities for action are created out of sociomaterial arrangements that instantiate histories of labor and more and less reliable, always contingent, future re-enactments. (Suchman 2006, p. 653)

In his recent book about his journey into Ishiguro's laboratory, robotic artist Zaven Paré qualifies this laboratory as a strange theatre that displaces experimental certitudes (Paré and Grimaud 2011). He reports that when Ishiguro's robot moves, something happens with its performance: a minute movement of the fingers combined with an ocular contact becomes a perfect moment of synchronicity that nobody expects. “Something happened!” and the lab team gets suddenly agitated around the robot while the experimenters were not even ready for it. This event surpasses the robot itself and its intrinsic capabilities.

Figure 7. Ishiguro and his doppelgänger
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Ishiguro’s geminoids and actroids are unsurpassed in their imitation of human skin texture, hair, facial expression etc. But in the heart of the actroid lie mechatronics and mechanical principles that are similar to those found three centuries ago. Moreover, in an almost fraudulent fashion, a remote operator accomplishes the actual animation of the high-level behaviours (speaking per se) of the android.

1.3.3. Concealing the animated, revealing the animate

In conclusion, Mumford’s analysis, tied into a criticism of the Industrial Revolution and automation, was focused on how technology impacts a society at large in its relation to *machine performers*. Even though Mumford’s criticism was confined to industrial settings, it can easily be applied to the perception of *machine performers* today, because robotics is also filled with unsatisfied promises that have become almost mythical. Some examples might be: the superiority of the artificial brain, the virtuosity of the robot, and its foreseen ubiquitous role as a servant (Brooks 2002) .

Unfortunately, many typical presentations of robots are still mystifying and not easily explicable. Two robots of two different eras have reached stardom in their respective times: The *Chess Player* and Ishiguro's *Geminoid*. In both cases, these agents are not capable of performing anything on their own. Their agency is brought to life by "borrowed minds" – a la Tesla – residing outside their bodies in the form of a remote control operator. These robots hit the imagination of society by what they represent, not by what they actually are: sophisticated hoaxes. Ishiguro to some extent revives Kircher's magical insider jokes with his menagerie of actroids and geminoids. I can actually ask about the real object of these machines, as Riskin asks of Vaucanson's duck: "What, then, is the meaning of this hybrid animal, partly fraudulent and partly genuine, partly mechanical and partly (ostensibly) chemical, partly transparent and partly ingeniously opaque?" (p. 609).

In my own work this kind of mystification has no relevance. Its aim is too literal. I think that in order to encourage audience empathy towards *machine performers*, each member of the audience has to understand the embodied robot in their own way as it performs live in front of their eyes.

I have shown in these examples that staging adds capabilities to the machine without actually having to fully implement them. In my own work, the direction of audience attention and exploitation of what the eyes see (or don't see) does not aim at hiding but at exploring and enhancing the limitations of the *machine performers*.

Figure 8 shows two constructions: an automaton from the *Treatise on Pneumatics* written by Hero of Alexandria (circa AD 63) and the Cube, a machine performer from *Devolution* (full description of the work in Chapter 4). Hero created a series of devices to dupe the faithful into believing that the doors of the temple were opened by divine power. This was a "cause to effect" swindle, as the person who lit the fire in the atrium would "magically" open the doors of the temple by means of the pneumatic principles illustrated below. The Cube is a large-scale articulated structure that morphs from geometrical to more organic shapes. Though the Cube has a fairly limited vocabulary of expression, its analogy to the *deus ex machina*[4] found in Greek theatre enhances its role and character, as well as the audience's perception. In both cases, the doors and the cube apparently move independently of visible human action (pneumatic systems in both situations). However, *Devolution*'s audience would not be duped by the invisible means that move the Cube's structure. Twenty-first century viewers will undoubtedly try to establish a rationale for the abstract movement of this complex articulated structure, in line with their power to resolve the plots of other *deus ex machina* devices.

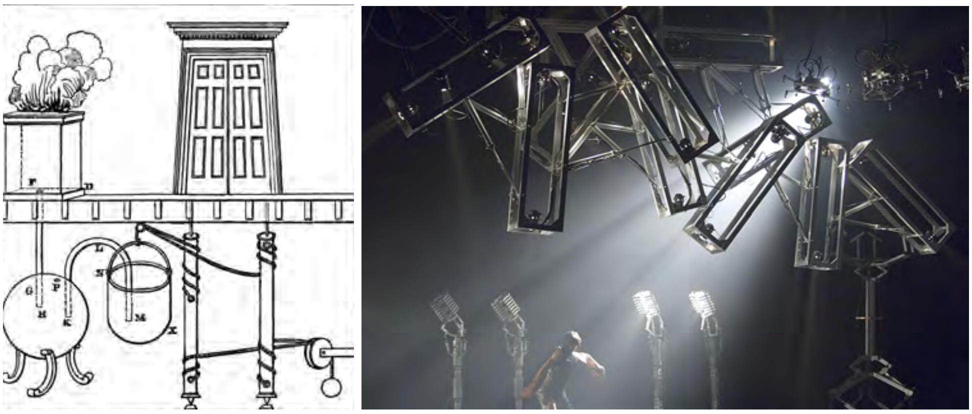

Figure 8. Heron of Alexandria's temple door-opener (circa 60AD) and *Devolution*'s Cube (2006)

Current theorists like Wood posit that the disguise found in automatons like those of Jacquet-Droz often reveals the intentional disguise of the makers. In contrast, my own intention is to build machines that are reduced to their skeletons and display bodily morphologies that are not embellished by aesthetic artefacts. Far from helping the embodiment, the level of mimicry present in Jacquet-Droz automatons is just cleverly dressed up mechanics.

In a similar way, media can dress up the results of machine performance and fictionalise its reality. I agree with Weber that the framing and editing of the media can certainly help to hide the malfunctions of robots. However, in a live presentation, the audience always receives an "unedited" version of events. Perhaps by integrating these malfunctions, I can integrate these "misbehaviours" of the *machine performers* directly into the dramaturgy.

4 A god lowered by stage machinery to resolve a plot or extricate the protagonist from a difficult situation.

Table 5 summarises the animate-animated equation of this section, where the animation act aims on the one hand to reveal the object as animate, and on the other to conceal its animation. When the technological and the magical blur[5], a "miracle" of animism – as opposed to one of performativity – happens. The chess automaton, like that found in industrialisation, hides the depersonalisation of automation and cybernetic art (Turner 2008).

	Animate (The animation act aims to reveal the object as animate)	**Animated** (The animation act aims at its own concealment)
Cellini's sculpture.	Directed focus can hide the animator.	People move the sculptures
Special Effects of Kircher.	Spectators cannot distinguish magic from technology.	Initiated members understand the magical perception of magnetism
Musical Lady	Automatons perform human activities and are staged as fragile and likeable characters.	
Chess Player	The vis-motrix and vis-directrix were considered as aligned in the *Chess Player.* Belief induced by thaumaturgical means.	A person hidden inside provided both the vis-motrix and vis-directrix. Scepticism in this era, as other Kempelen machines were considered mechanical.
Vaucanson's defecating duck.	Non-mechanical nature of the behaviour classifies it as animal, therefore animate.	Not only a hoax but also a (merely) complex mechanism.
Cloaca	Excrement is real and tested as human.	Presented as a complex apparatus comprising opaque processes.
Heron of Alexandria	Spectators only see the effect and cannot find the cause.	Hidden mechanics and pneumatics.
Ishiguro's *Geminoid*	Spectators are focused on the verisimilitude and rejoice when a human behaviour happens (by accident)	Intelligence and agency vested in a human teleoperator.
Devolution's Cube	Perceived organic motion makes the structure more animate. Its behaviour has no apparent cause or effect.	Presented as a mechanical structure.

Table 5. Animate and animated, revealed and concealed

1.4. Mechanisation of man, humanisation of machines

Since the 18th century, the automaton has acted as the manifestation of the emergence of artificial life, broadly described by Riskin as "an attempt to simulate with machinery the physiological processes and cognitive behaviours of living creatures" (Riskin 2003, p. 97).

5 This refers to a quote from popular scientist and novelist Arthur C. Clarke: "Any sufficiently advanced technology is indistinguishable from magic."

In recent times, the automaton has undergone several transformations from the dependent automation of the early Industrial Revolution to the semi-automation found in the early 20th century and finally, to the full automation of mid 20th century computerized automatic machinery. Tomas argues that "By the late 1940's confusions arising from competing images of the human body as a thinking organism were effectively exorcized through an anti-mimetic shift in the history of automata" (Tomas 1995, p. 27).

I will be using this anti-mimetic shift as the first pivotal point of the recent history of automatons. I will show that prior to this point, the automaton was about explaining and even employing man as a machine. I will bring examples of theatre genres of this era and discuss how they saw man as a machine-performer. Afterwards, cybernetics started turning the machine into a man, paving the way for the appearance of social robotics.

When Riskin examines the tension between the animal and the machine – which Stacey and Suchman label the 'animate' and the 'animated' – an ongoing shift appears in the boundaries between the two categories. This ongoing ontological questioning and repositioning is summarised in the following way by Riskin:

> […] we believe that the processes of life and consciousness are essentially mechanistic and can therefore be simulated, and yet we are equally firmly persuaded that the essences of life and consciousness will ultimately be beyond the reach of mechanical reproduction. (Riskin 2003, p. 97)

For instance, such a cycle can be found in the late 20th century, where (nouvelle) artificial intelligence moved from the harder mechanistic vision of cybernetics towards embodiment, almost abandoning the cybernetic computer models required to simulate life. Afterwards, AI had to re-integrate earlier models in order to bootstrap the implementation of these earlier, radical embodiment concepts.

1.4.1. The human machine

In the course of various artistic movements the early 20th century has given us several different views of the "mechanical body". Čapek wrote his 'play about Robots' at the beginning of the 20th century, and this owes its inspiration in machine aesthetics to the 'rational' avant-garde artistic movements of Futurism, Constructivism and the

Bauhaus. Even in Surrealism we can find the principle of creativity based on an autonomous mechanism (automatism) of the dream. Avant-garde artists' attitudes towards the machine vary widely, from the Futurist and Constructivist adoration of the machine to the fear and scepticism connected with human confrontation with non-human machinist systems that transcend the individual (e.g. Expressionism).

Filippo Tommaso Marinetti, the founder of Italian Futurism, wrote in his manifesto "Multiplied Man and the Reign of the Machine": "Engines […] are really mysterious […] They have their moods, unexpected bugs. It seems that they have personality, soul, will. It is necessary to stroke them and behave with respect to them […]." (Schmidt-Bergmann 1993, p. 108). The quotation reveals the anthropomorphic, anthropopathic Futurist understanding of the machine as a system complementary or analogical to the human. From this understanding springs the concept of the 'man-machine' as an ideal member of modern society, a fusion arising from harmonisation and mutual resonance, the ideal of the modern person as an individual equipped with mechanical qualities such as speed, dynamics, or ambiguous moral attitudes.

A positive relationship to the machine can also be found in Russian Constructivism. In contrast to Italian Futurism, Constructivism had a more complex understanding of technology and at the same time a collective understanding of the human. A significant example of Constructivist aesthetics is Meyerhold's theatrical *Biomechanics* – a series of exercises for actors that purports to give them the ability to control their bodies as instruments or machines. Meyerhold himself said about his method:

> According to the given study of the human organism, biomechanics try to raise a man that would examine mechanism of his construction, he would perfectly control and complete it. Contemporary man lives in an age of mechanization that can't ignore mechanization of his organism's kinetic system. Thanks to Biomechanics we will establish principles of exactly analyzed and performed motions […] Contemporary actors have to behave as a modern automobile on a stage. (Rudnickij 1969)

According to Constructivism, the stage becomes a place where the human machine is presented as regulated by the directors who are its designers and engineers.

When they dreamed of the superman of the future, the Futurists invoked the concept of man as an unloving automaton, whereas the Constructivist stage production was seen as a mega-machine constituted of human components – in other words, human group performance was understood as a mega-machine production. This discourse led directly to the conceptual mechanisation of man and the anthropomorphisation of the machine. In both cases we can talk about the mirroring of the human in the machine and the machine in the human.

Part of this relatively early evolutionary line of theatrical experiment inspired by machinist aesthetics was a series of theatrical performances on the Bauhaus stage. Schlemmer's theatrical experiments were a search for "elements of movement and space" (Goldberg 2011). The inspiration he drew from visual art was reflected in his understanding of dancers as objects on the stage. His performances evoked a mechanical effect reminiscent of puppet theatre. We can read in Schlemmer's diary (1971): "Might not the dancers be real puppets, moved by strings, or better still, self-propelled by means of practice mechanism, almost free of human intervention, at most directed by remote control?" (Schlemmer and Schlemmer 1990). From 1923, puppets, mechanical figures, masks and geometrical costumes became a characteristic feature of many theatrical performances of the Bauhaus. Another Bauhaus member, Moholy-Nagy (1924) went even further in the *The Mechanized Eccentric (Die mechanische Exzentrik):*

> Man, who no longer should be permitted to represent himself as a phenomenon of spirit and mind […]. His organism permits him at best only a certain range of action, dependent entirely on his natural body mechanism […]. The effect of this body mechanism (Körpermechanik) arises essentially from the spectator's astonishment […]. This is a subjective effect. Here the human body is the sole medium of configuration (Gestaltung). For the purposes of an objective Gestaltung of movement this medium is limited, the more so since it has constant reference to sensible and perceptive (i.e. again literary) elements. The inadequacy of *human* Exzentrik led to the demand for a precise and fully controlled organization of form and motion, intended to be a synthesis of dynamically contrasting phenomena (space, form, motion, sound, and light). This is the Mechanized Eccentric. (Schlemmer, Moholy-Nagy et al. 1996)

Schlemmer's dream of an ideal stage representation of man as a puppet, like the Futurists' dreams of a human-machine or Meyerhold´s biomechanics, resonates with the developed vision of modern theatre. A New Theatre as an independent and fully-fledged artistic medium, represented by Craig's vision in which actors are replaced by super-puppets, entirely controlled by the stage director: "An actor has to be removed and at his place, will appear an unloving figure, super-puppet, as we will call it until it will get a better name" (Craig 1912). This utopian theatre of objects has its roots not only in the aesthetics of symbolist theatre but even more deeply in Romanticism.

We can find the essence of the Romantic understanding of puppets in Heinrich von Kleist´s essay *Über das Marionettentheater* (1810/11). Paul de Man in his essay *Aesthetic formalisation: Kleist´s Über das Marionettentheater* (De Man 1984) confronts Kleist's text with Schillers' concept of humankind's education through aesthetics and shows that in the case of Kleist's essay we are dealing with the embodiment of principles of aesthetic formalisation:

> Each puppet has a focal point in movement, a center of gravity, and when this center is moved, the limbs follow without additional handling. The limbs are pendulums, echoing automatically the movement of the center. Every time the center of gravity is guided in a straight line, the limbs describe curves that complement and extend the basically simple movement. (De Man 1984)

It is impossible to interpret and understand robots and robotic art outside the context of culture and history, or outside the different connotations and associations connected with the word 'robot'.[6] This word appeared for the first time in the play *R. U. R., Rossum Universal Robots* (National Theatre, Prague, 1921) by the Czech writer Karel Čapek.[7] Figure 9 (left) shows the robot embodiment in the first official stage production of the play, whereas the right hand image shows the robot as a puppet/apparatus in a later Parisian production of 1924. The variation between the mechanized man on the left and the humanoid machine on the right indicates an interpretative shift towards the conceptualisation of the robot during the 20th century (Horáková and Kelemen 2005; Horáková 2006).

Karel Čapek's anecdotal account of the idea that inspired his decision to write a 'play about Robots' shows his understanding of the robot as an embodiment of the contemporary image of man as a creature formed by industrial mass production:

> Robots were a result of my travelling by tram […]. People were stuffed inside as well as on stairs, not as sheep but as machines. I started to think about humans not as individuals but as machines and on my way home I was thinking about an expression that would refer to humans capable of work but not of thinking. This idea is expressed by a Czech word robot.[8]

6 The word 'robot' is a neologism derived etymologically from the archaic Czech word robota, which means drudgery or chores in the Czech language.
7 R.U.R. is interpreted as a comedy of confusion in which we are not able to distinguish between man and Robots.Wood, G. (2002). Edison's Eve. A Magic History of the Quest for Mechanical Life. New York, New York, Anchor Books, a division of Random House.
8 Čapek, K. Evening Standard (June 2, 1924). In Čapek, K. R.U.R. Halík, M. (ed.) Československý spisovatel, Praha, 1966.

Čapek connected his Robots with the history of artificial creatures, specifically with the Prague golem legend, when he said: “R.U.R. is in fact a transformation of the Golem legend into a modern form […]. Robots are factory mass-produced Golems”.

A further understanding of the origins of the robot character can be derived from the many other artificial creatures created by Čapek brothers. The short story *Systém* (*System*) (1908/18) is often mentioned as an earlier version of the *R. U. R.* plot. The story is based on the idea of “culturally reformed” workers trimmed and adjusted exclusively for manual work. In the *Instructive Story* (1908) and *L’éventail* (1908/16) the brothers brought into their fiction the figure of Jacquet-Droz (see previous section) as a real character, along with his fictitious mechanical androids (see Figure 10).

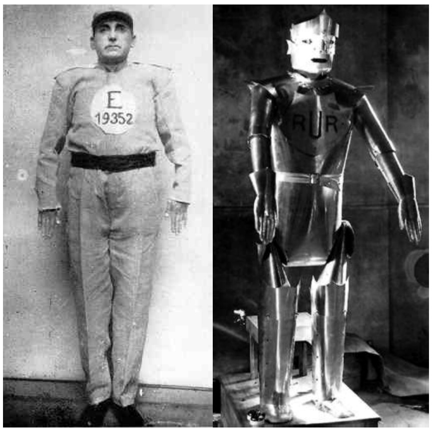

Figure 9. Robot character from RUR. Left, first night in Prague. Right, later in Paris (1921) (Horáková 2011)
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The theme of the mechanical humanoid machine is present in separate work by Josef Čapek, the real author of the word *robot*, as well. One instance appeared as a “mechanical alter-ego” constructed by an engineer in his short story *Opilec* (*The Drunkard*) included in the collection *Lelio* (1917). However, the mechanical double is called simply “mechanism”, not ‘Robot’ in that story. The artistic essay *Homo Artefactus* (1924) by Josef Čapek is both a recapitulation and a satirical commentary on the theme of the artificial man that appeared at the beginning of the 20th century as a notion of the “new man”.

Figure 10. *L'éventail* - Lady with a fan. She is able to say only "si" or "no".
Illustration from J. Čapek´s *Homo Artefactus* (1924)(Horakova 2006)
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1.4.2. The mechanical human

Cybernetics in the mid 1960s managed to create an immense fear of the machine, blurring the boundaries between man and organisms, as contemporary advances in intelligent computers forced people to reconsider the nature of human intelligence. Machines and technology became part of what it meant to be human (Hong 2004). However, the kind of mechanisms and servo-mechanisms used by earlier clockwork and industrial automation systems were not that different in their operational logic. The difference was that cybernetics penetrated the social dimension in a wide variety of forms beyond the industrial (Tomas p. 24).

During this period, the success of cybernetics brought a revolution in human thought and perception through a set of analogies, sometimes oversimplified, such as: the body as a nervous system with sense-organs, the machine as a communicating organism, and societies as networks of machines linked via a common communications language. Automatons elevated to the level of cybernetics were now sensing their environments, adjusting via feedback mechanisms enabling them to regulate future conduct by past performances. These automatons were then considered active, self-regulated and goal-oriented; a few steps away from the dystopian science-fiction scenarios of machines overtaking, and taking over, man.

Cybernetics brought a fundamental distinction between mimetic and functional analogies. For instance, the brain analogy was based on a view of mechanical function. Cherry wrote: "It is not the machine which is mechanistically analogous to the brain but rather the operation of the machine plus the instructions we fed into it (Cherry 1957,pp. 57-58). And Tomas concludes: “Cybernetics operationalized the question of ‘life’ by displacing the concept of organism from biology to engineering, thus effectively transforming it into a hardware problem” (Tomas 1995, p. 26).

As we saw in the previous section, the beginnings of artistic investigation using electronic technologies were rooted in just such a cybernetic view of systems: a world of signal reproduction where organisms had shifted from biology to engineering, transforming them into hardware/software models. As David Tomas states, cybernetics is a world of automatic machines under the common denominator of “control and communication”.

This operationalization of the living organism led to the conception of a hybrid: the cyborg. In the 1960s, the term ‘cyborg’[9] was introduced at a time of intense concern over automation. The cyborg was a hybrid system of both artefact and organism originally conceived to perform in a highly mechanized environment such as a spaceship (Hong 2004). The cyborg could also function as a figure of the rejection of anthropocentric views, further blurring and questioning borders between humans and machines (Kelemen 2010). In her seminal manifesto, Danna Haraway dealt with these irreconcilable positions: “Cyborg imagery can suggest a way out of the maze of dualisms in which we have explained our bodies and our tools to ourselves” (Haraway 1991). Simon Penny claims that:

> Cybernetics was the first generation of thinking about the qualities of the biological life with respect to computational machines. In contradistinction to Artificial Intelligence, cybernetics saw intelligence in terms of environmentally situated agents, involved in feedback and homeostatis with their environments. (Penny 2012, p. 93)

And Penny further argues that:

> As digital computation developed, its rhetoric took an antithetical position to that of cybernetics: dualist (hardware/software) where cybernetics was holistic; internalist where cybernetics was externalist; and representational where cybernetics was, one might say, performative” (Penny 2012, p. 93).

The artificial intelligence that Penny refers to is what some have called Good Old-Fashioned AI (GOFAI) which is best described, in its spirit, by the Dartmouth Artificial Intelligence Project Proposal of 1955, the community convened under the assumption that:

9 Coined by Mansfield Clynes and Nathan Kline of the American Space Progam.

> We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer. (McCarthy, Minsky et al. 2006, p. 13)

This original idea of AI dominated until the mid-1980s as a challenging approach. AI then shifted from symbol processing to behaviour-based and biologically inspired topics. Following this, the notion of "embodiment" surfaced in the field, the concept being that intelligent behaviour is not only a matter of computation, but requires a body, a complete organism that interacts with the real world. As a consequence, many researchers have shifted their attention away from the central brain (the computer) towards embodiment (robots) (Brooks 2002; Pfeifer et al. 2007). Many AI theorists see this as a transfer from a top-down towards a bottom-up approach, summarized by Suchman in the following words:

> The less visible and somewhat restrained AI projects of the 1990's play down the personification of machines in favor of biologically-inspired computer science and engineering initiatives aimed at recreating artificial life forms, via the technologies of neural networks, genetic algorithms, situated robotics, and the like. These new developments shift the project of machine intelligence away from what is now referred to as "good old fashioned symbolic information processing" AI, toward a technical practice based in more foundational metaphors of biosocial evolution and, in Sarah Franklin's phrase, "life itself." (Suchman 2003, p. 1)

Neurophysiologist Grey Walter, one of the first opponents of this simulation and modellisation of GOFAI, wanted a new way to visit the workings of the brain. He constructed small mobile robots to show that, beyond cognitive organisation, anatomical and bodily characteristics determine behaviour (Walter 1950; Cordeschi 2002). In contrast, the *Sexed robots* of artist Paul Granjon are a pastiche of Walter's work and similar autonomous behaviour-based robotic experiments. Granjon reminds us of this mechanical reduction of a living system by automating mating rituals into a mundane interplay of sensors and a reduced set of internal bodily states.

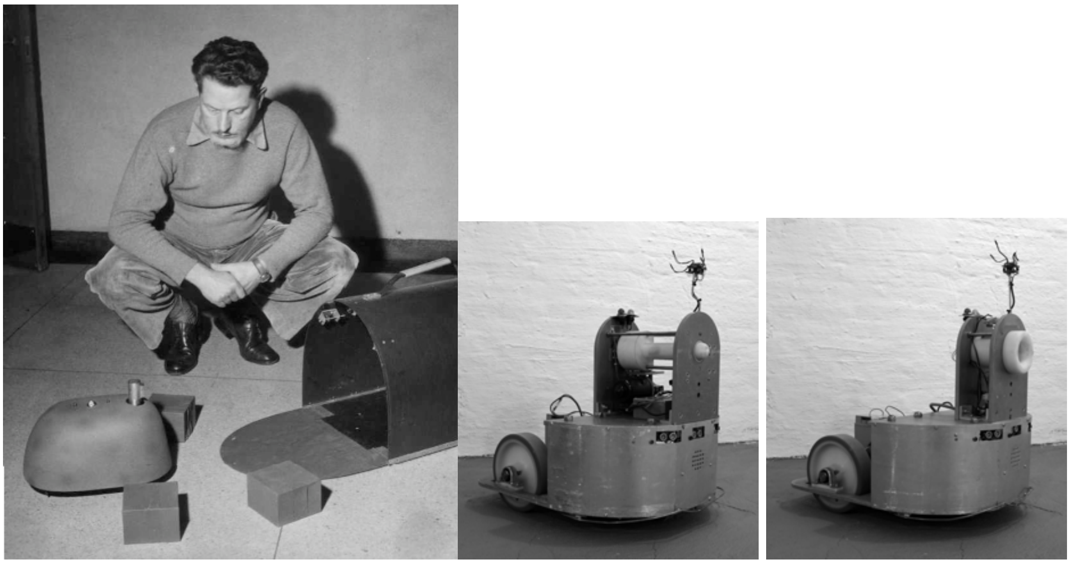

Figure 11. A *Tortoise* by Walter (left). *Sexed Robots* by artist Paul Granjon(right)
Permission to reproduce Tortoise image has been granted by IEEE. Permission to reproduce *Sexed Robots* images has been granted by the artist.

1.4.3. Life as it might be? Life and behaviour-based machines

To qualify an entity as 'living' was not a concern for Wiener's cybernetic view of organisms:

> Now that certain analogies of behaviour are being observed between the machine and the living organism, the problem as to whether the machine is alive or not is, for our purposes, semantic and we are at liberty to answer it one way or another as best suits our convenience. (Wiener 1954, p. 32)

However, the very definition of 'living' became a field of interest as an outgrowth of the field of artificial intelligence. In 1987, during a workshop on Artificial Life, Langton and other participants defined the basis of this scientific field. Artificial Life was about the simulation and synthesis of living things. Rather than a force, Langton saw life as "a property of the organization of matter" (Langton 1989). In the vein of cybernetics, life manifests itself in A-Life in behaviours, in its abstract dynamic, which is not necessarily based on a biological medium (Whitelaw 2004). The philosophy of A-Life included a new motif, unspoken by, but yet present in, cybernetics: studying not only "life-as-we-know-it", but also "life-as-it-might-be". A subset of A-life, Real Artificial Life, concentrated on robotics as a "metaphor" of living systems.

Riskin's definition of A-life included a motif of simulation while Langton's sought for the roots of the mechanisms of living in both organic and inert systems. A-

Life as an art form followed the path opened by this A-Life as a scientific investigation:

> There is no single feature that characterizes the unique nature of Artificial Life (A-Life) creativity in art. Rather, there is a set of characteristics, some of which will appear in any given work. For example, A-Life artworks might have behaviors, while other artworks do not; they are not static but dynamic and may evolve over time in relation to their environments; or they might incorporate both natural and artificial elements, calling into question the boundary between the living and the nonliving. These are A-Life research concepts that, through A-Life art, find their way into people's imaginations in a way that they otherwise could not and in a form that allows them to be directly experienced and readily understood. A-Life art is a synthesis of different cultural inputs: the technological buzz of the moment, ideas from research that are sometimes highly specialized, and whatever artistic strategies must be called upon to mold these diverse forces into an artifact that has both aesthetic power and social relevance. (Tenhaaf 2008)

1.4.4. Life as we know it? Social machines

In an anthropocentric view of "A-Life", AI was seen in the early 21st century to be evolving into socially driven artefacts:

> Nonetheless, attributions of human-like machine agency seem alive as ever in both professional and popular discourse. The growth of the internet in particular has brought with it a renewed interest in the idea of personified computational artifacts attributed with a capacity for intelligent, interactive behavior. (Suchman 2003)

In line with their opposing concepts of intelligence as either Cartesian or embodied, roboticists have taken opposite paths in their simulation of life: the artificial human on the one hand and biomimicry (the rest of the living) on the other. From an external perspective, mimicking biology can be seen as embracing the natural, while conjuring the inanimate human body embraces the artificial. Governed by this overriding view of life, AI is nowadays split between two schools of thought: "strong" versus "weak" AI, "top-down" versus "bottom-up", or the proponents of symbolic computation versus the advocates of embodied intelligence. Artificial versus natural cycles surface again in the robotic field, as developed in this chapter in the form of the animated versus the animate.

Social robotics typically involves an assemblage of intercommunicating components put together onto a frame (body): vision, hearing, speaking, facial expression, bodily expression and locomotion. While "life" seems, in "bottom-up" AI, to emerge out of simple components interacting with their environment, social robotics goes a step further, imitating "life" as a complex set of human interactions. Its high-level functions, like conveying emotions, are very much modelled on top-down AI symbolic processing. Hence the body movements of social robots are seen as incidental to supporting "social functions" such as gaze and facial expression. In fact, the sensation of life conveyed by social robots is itself the subject of controversy. In the first place, the dualist Cartesian approach found in this field insufflates a rejection phenomenon called the Uncanny Valley that will be discussed extensively in Chapter 2. And secondly, since the approach of social robotics remains mechanistic rather than truly embodied, it will experience considerable difficulty facing the challenge of generating animate offspring.

Figure 12. *Kismet* (Brazeal) and *Palmipède* (Boyer)
Permission to reproduce *Kismet* image has been granted by IEEE. Permission to reproduce *Palmipède* image has been granted by the artist.

Figure 12 brings two robots formed out of assemblages of different components. On the left, *Kismet* by MIT's Cynthia Brazeal is a complicated machine that engages with people socially. *Kismet* possesses specialized mechanical systems to convey its emotions and predispositions. On the right, *Palmipède* by artist Gerard Boyer is a simple mechanical construct made of a car's gearbox driving two diver's flippers. The resulting gait of this machine is unpredictable, yet resembles a clumsy bipedal animal. *Palmipède* can only walk while *Kismet* is gifted with a wider range of capacities. Nonetheless, *Palmipède* feels very animate, an empathic scenario of a per se credible animal trapped by its limitation, while *Kismet*'s assembly of friendly gestures feels overacted, a collage not yet integrated into holistic bodily experience.

1.4.5. Animate-animated shifting borders

In conclusion, this past century has moved from the mechanically inspired robot to yet another dualistic tension. On one side stands the biologically inspired machine that mimics existing organisms, on the other the humanly inspired social composition that attempts to faithfully replicate the human in all its facets.

In the early part of the century, a time both fascinated and terrified by the latent dangers of industrialisation, Futurism breached the lineage of strictly human replication. Even though less anthropocentric, I see a great deal of transference between humans and machines in Futurism, and the human is still central in Futurist thinking.

In its claims, the Bauhaus Theatre attempted to evacuate the human from the theatre equation, therefore freeing the performance from text and transforming it into pure movement and form. However, even within this scheme the human remained present (as the borrowed mind of Tesla's submarines), perhaps waiting for the upcoming autonomy of the machine or for greater mechanical virtuosity. On the Bauhaus stage, audiences saw abstract images of human bodies reduced to geometrical shapes that referred to an urge to depict the essence of the human not in its individual uniqueness, but in its general sense and universal validity. In the case of the Bauhaus, I consider these machine-like or puppet-like bodies as (generalising) mirrors of the human, or a deconstruction of that construct into a visual language of geometric form.

Complete autonomy of the machine was certainly approached by the Čapek brothers. The word 'robot' was coined by this duo, but it has been re-appropriated in various forms and contexts to fulfil the aura of the myth of the mechanical double. Close to Cartesian thinking, the link and boundary line between the human and the machine is, for the Čapek brothers, the soul.

The "soul" of the machine became a social concern during the 1960s. With advances (and promises) by artificial intelligence and new models representing the biological combined with the electronic, this era faced a diffuse sense of fear of the machine. Cybernetics generated many utopian and dystopian views of machines that were becoming increasingly autonomous. Fuelled by science-fiction and the climate of the time (nuclear proliferation, the Cold War), a machine with a sense of inner motivation and self-regulation (man outside the loop) generated widespread distrust of the mechanical.

In my own work, the sense of being animate in a robot is not to be confused with a sense of autonomy. In Chapters 3 and 4 I will discuss at length the minute variations in autonomy, agency and lifelikeness involved in locating the vis-motrix and the vis-directrix of my *machine performers*.

Finally, Dana Haraway's posthumanist "Cyborg manifesto" summarized late 20th century developments in the cycle of the animal versus machine definition:

> The second leaky distinction is between animal-human (organism) and machine. Pre-cybernetic machines could be haunted; there was always the spectre of the ghost in the machine. This dualism structured the dialogue between materialism and idealism that was settled by a dialectical progeny, called spirit or history, according to taste. But basically machines were not self-moving, self-designing, and autonomous. They could not achieve man's dream, only mock it. They were not man, an author to himself, but only a caricature of that masculinist reproductive dream. To think they were otherwise was paranoid. Now we are not so sure. Late twentieth-century machines have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines. Our machines are disturbingly lively, and we ourselves frighteningly inert.(Haraway 1991, p. 120)

	Animate	**Animated**
Artificial intelligence	Biomimicry (part of nouvelle AI) copies behaviours found in nature.	GOFAI is a Cartesian view of the body. The brain is the symbolic processor and controls all the body (effectors).
Man as Machine	Non-anthropocentric view of the role of the human body on the stage. Seeking the animate of the human body in its essence. Kleist, Futurists, Moholy-Nagy.	Still anthropocentric view of the glorified human, either as a silent abstract figure or as a utopian product. Schlemmer, Meyerhold.
Machine as Man	Čapek's robots are machines with souls. R.U.R.	*L'Eventail* has a limited functionality for the stage. In fact it is intended to feel animated.
A-Life	*Palmipède*'s movements are not modelled, they simply happen. Hence the behaviours have the complexity of the living.	Though Walter's *Tortoise* was probably first seen as animate, the internal mechanisms lack integration into the environment.
Social Robots		*Sexed Robots* are conceptualized as animated and ridicule the mechanization of the biological. Though *Kismet* can socially engage at many levels with the human, it feels manipulated.

Table 6. Animate vs. animated in the 20th century.

1.5. Contributing work: *La Cour des Miracles*

1.5.1. Description

In the 17th century "La Cour des Miracles" was a nickname for the slum districts of Paris. The name derived from the sudden "miraculous" disappearance of the pseudo-disabled found in various manifestations of beggary once the night had fallen. Actually most of these people were not disabled at all. These districts were dark, scary places where beggars, thieves, the crippled and the sick lived, discarded from society and hidden from the eyes of the bourgeoisie.

By creating a universe artificially loaded with affliction, the aim of a robotic *Cour des Miracles* is to induce an empathic response from the viewer towards characters that are merely articulated – though in some sense also articulate – metallic structures. The force of the simulacrum is heightened by perverting the perception of these 'animats'[10], which are neither animal nor human, stimulating an inevitable reflex of anthropomorphism and – in line with Aristotle's *Poetics* – the cathartic projection of the sensations of pity and fear.

Using the principle of evocation rather than representation, the installation space simulates a hypothetical habitat made for robotic characters. Viewers must traverse a long, narrow, "sordid" space located in an industrial-looking site. The machines are distributed along this confined corridor, crawling on the floor or hiding in dark corners. The close proximity of the machines challenges the viewer's comfort and impressions of physical safety. In her analysis of *La Cour* Tenhaaf thus concludes with the comment: "The robots show an unquestionable power in their abrasive clamour for attention, even with their very limited repertoire of movements and behaviours" (Tenhaaf 2008).

10 'Animats' are artificial animals, a subset of Artificial Life Studies. The word was coined by S.W. Wilson in 1985.

Six individual "characters" were originally created to perform under the dramaturgical theme of "robot misery":

- The Harassing Machine calls upon the passing viewer by shaking its articulated arms towards them. At the extremity of these members, small tentacles (agitated by compressed air) tease the intruders with importunate touches.
- The Limping Machine walks painfully towards the viewer, stumbling awkwardly because of a differently aligned or distorted member of its body.
- The Convulsive Machine is a thin metallic structure shaking with frequent but yet irregular spasms, especially when viewers approach.
- The Begging Machine rocks its trunk back and forth on its base and raises its mechanical arm towards the viewers walking by. In order to emphasize the solicitation, the beggar has a suction device fixed at the end of its articulated arm.
- The Heretic/Rebel Machine is locked up in a cage. When viewers come close by, it rushes violently towards them, grabs the metal grid and furiously shakes its cage.
- The Crawling Machine creeps laboriously on the floor. Slow and vulnerable, it tries to run desperately away from approaching viewers.

Figure 13. La Cour des Miracles at V2 (Demers-Vorn 1996). The Limping. The Untamed. The Convulsive. The Begging
Permission to reproduce these images has been granted by V2.

1.5.2. Presentations

La Cour was initially conceived as a set of six characters premiered at the International Symposium on Electronic Arts (ISEA) 1997. The following year, it was presented in a larger and more elaborate mise-en-scène (30 robots) at the Museum of Contemporary Arts of Montreal. Subsequently, *La Cour* was exhibited internationally and received first prize at VIDA 2.0, a high profile international contest focused on Artificial Life.

As part of their facility's grand opening in May 2012, Fundacion Telefonica decided to curate "Art and Artificial Life", a retrospective show involving most of the first-prize winners of past VIDA contests. *La Cour des Miracles* had to be reconstructed and refurbished for this retrospective, as it had been dismantled in early 2000.

With my collaborator Bill Vorn, we had to re-implement a subset of the full cast of characters, and consequently revisit their embodiments and actualize their programming. Back in 1997, *La Cour* already included a number of AI concepts and techniques such as subsumption programming architecture to implement behaviours (Brooks). At that time our approach to embodiment was intuitive, and it is only through this thesis research that I started to formalize the process. The AI-embodied behaviours of *La Cour des Miracles* were then actualised, redeveloped and examined within the context of this thesis. In Chapter 3 I will show how the bottom-up approaches of recent AI can be used to reinforce embodiment.

1.5.3. Embodiment and staging in La Cour

Given that these limited machines are augmented by their mise-en-scène, an examination of the context created by *La Cour des Miracles* and of the morphologies of its machine bodies will serve as a useful springboard for an analysis of the repercussions of embodiment in *machine performers*. The following principles will become apparent:

- As an artistic strategy, presenting the **disability** of the machine helps to emphasize notions of **embodiment.**

- *La Cour* reflects on an **historical** situation by combining different modes of **staging** (medieval, freak show, zoo) as opposed to a neutral museum exhibition (white box, silence, contemplation).

- By **deconstructing** stereotyped situations (e.g. *Asimo* showing his abilities to serve coffee) of scientific **presentations**, *La Cour* engenders an artistic scenario through its mise-en-scene.

1) Disability and embodiment

When audiences are faced with afflicted mechanical organisms not performing repetitive duties and predictable tasks but displaying rather tortuous and painful behaviours, these machines begin to evince a certain level of credibility. The divide between the disabled animats and the utopian conception of the "perfect machine", or the tool performing at a virtuoso level, challenges audience preconceptions.

These preconceptions are rooted in a clash between realism and the metaphor of the invented objects. In the context of *La Cour*, viewers have to imagine the normal behaviours (or normal bodies) of the *machine performers* as staged. In her analysis of (e)motional machines, Neumark describes *La Cour* in terms of its evading the instrumental logic of social robots:

> Though interesting for its recognition of emotion, the creativity of affective computing is itself blocked by its instrumental logic. It is this logic that produces the famous emotive talking computer, Kismet, as blandly 'cute' and what is called 'expressive synthesized speech' as dully functional. Even in much media art, the attempt to simulate and "model how objects and humans act, react, move, grow, evolve, think and feel," has been driven by the logic of realism. […] However, there are artists who are exploring the edge of AI with works which are not about the instrumentality of either cuteness or realism, but which express startling and frightening and bizarre and other irreducibly intense, if strange, emotions. (Neumark 2001)

Likewise, in her essay on Artificial Life and the VIDA Competition, Tenhaaf summarises the disabled machine as a form of protest against the instrumental purpose of machines:

> Because works that are autonomous artificial agents become metonyms for technology itself (the part stands for the whole), their dysfunctionality or defiance of instrumental purpose truly stands in protest against the instrumental values we have realized in technology. (Tenhaaf 2008), p.14)

As performance theorist Stanton Garner has argued, the representation and perception of pain from the performing body – as in *La Cour*'s disabled, pain-racked bodies – fuses the fictional and the actual, providing rich ground for the phenomenologist of theatre:

> Thus the performing body occupies a paradoxical role as both the activating agent of such dualities as presentation/representation, sign/referent, reality/illusion and that which most dramatically threatens to collapse them. This is one reason why the staging of pain – prevalent throughout the history of drama and of particularly intense interest in the contemporary theater – is of such potential usefulness to the theater phenomenologist: in its evocation of corporeal duress, the suffering body brings to the point of crisis the body's representational volatility, and it casts in relief the experiential exchanges of character, actor, and spectator. The "performance" of pain invades, and is in turn invaded by, the perceptual actuality of pain in a way that foregrounds the uncanny circuitry and ambiguity of dramatic representation itself. (Garner 1994,pp. 44-45)

In "Bodies in commotion: disability & performance", Auslander & Sandhal remark:

> similarly, to think of disability not as a physical condition but as a way of interacting with a world that is frequently inhospitable is to think of disability in performative terms – as something one does rather than something one is. (Sandahl and Auslander 2005, p. 10)

One might argue analogously that the effect of focusing the interpretation of the *machine performer* in *La Cour* on its phenomenological body rather than on its mind (control of the muscles, reactions) is that the perceived behaviours manifested by the robotic agents are not ascribed to the machines' programs but rendered immediately live.

This is the pivotal point of these machines. The implementation of various afflicted behaviours is not via top-down processes. On the contrary, they are a set of muscular vibrations that, in collaboration with the machine morphology and according to audience proximity, make the robot tremble, collapse and so forth. For example, the convulsive machine's spasm qualities (spontaneity, tension, surges) are not programmed but "computed" by its body structure. The limbs of the machines are preloaded with tension, implementing a chaotic system, and a minute change in one limb can shift the whole machine to a different position. Likewise, the limping machine emanates a sense of helplessness, as the viewer directly witnesses the effect of the machine's weight falling on the floor. A viewer's folk physics[11] and folk psychology[12] will conclude that the machine does not have sufficient power to resume its nominal position. These bodily manifestations shift the perception of the movements of the robots from a sensation of imposed programmed functional behaviours (something one *is*) to a quasi-disappearance of the program (something one *does*).

La Cour certainly employs lures (as much as the real characters of La Cour did) but rejects the thaumaturgical strategies (Turkish *Chess Player*, Kircher) and falsification (Weber) of the past. The embodied weak situation of the robot is presented directly, appearing live in the front of the viewers. *La Cour* does not camouflage the limitations of the machines but rather directly exposes and exploits these limitations to generate empathy in the viewer. In this sense, the credibility of the robot is augmented.

2) Staging

In scientific discourse about machines, the environment is usually described as the space sensed and acted upon by the agent. Hence an object bolted to the floor or restrained by a chain would simply be described as constrained (variables). Artistically, however, an object bolted to the floor is perceived as suffering for some heinous reason. In *La Cour des Miracles*, the robots are helpless or condemned (bolted to the floor, in cages, failing to accomplish simple tasks) and this mise-en-scène helps the audience to accept the lures and empathise with the situation.

The cultural codes (stereotypes) of presenting and collecting oddities or rarities are numerous: e.g. the zoo, the museum, the freak show, and the circus. Any of these mises-en-scène can supply a frame for perceiving movements and behaviours. In *Bodies in Commotion* Auslander and Sandhal have this to say about staging disability:

> Manipulating and transforming stereotypes are important tactics, since the available scripts of disability – both in daily life and in representation – are frustatingly limited and deeply entrenched in the cultural imagination (Sandahl and Auslander 2005, p. 3).

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[11] Human perception of basic physical phenomena.

[12] Innate capacity to explain and predict the behavior and mental state of other people Horáková, J. (2005). "RUR, A Comedy about Robots." DISK, a selection from the journal for the study of dramatic arts **1**: 86-103..

Considering *La Cour* as a freak show (presenting its biological rarities) highlights a tension between science and art, for it is usually acceptable to display oddities and human monstrosities only for the purposes of science. Loaded with negative cultural connotations, the freak show is popular only in the underground layers of society.

In her essay *Theatre, Fear and Space*, architect Maya Öztürk approaches the site of the stage as a physical component of theatrical praxis: “It seeks to acknowledge that a subtle dimension of space, the ‘bodily’ and unmediated, can trigger an experiential mode, infused with feelings, and bearing on the ontological” (Öztürk 2010, p. 296). Writing about the exposure of the body to space, she claims that space can magnify the perceptions and goes on to observe that:

> Validating the absorbing qualities of the immediate, these are viscerally felt, as much a potential for response to sensibility as a pathway to awareness, especially while, acknowledged by the body, they condense in a fairly stable cluster of discrete occurrences and processes that constitute a form of experience. (Öztürk 2010, p. 312)

In *La Cour,* space does not actually pose a threat. However, the dark and hazy lair invented for the machine characters resonates with the physically situated body of the audience. Far removed from either the scientific laboratory presentation or the neutral ‘white box’ setting of the museum, the environment immerses the audience immediately, and the perceived behaviours of the characters of *La Cour* are mediated and modulated by the interface between audience and machine. Audience participation thus becomes an act of experience instead of an act of admiration (passive observation).

3) Deconstructing presentation

By putting the robot in a weak situation, *La Cour* proposes its afflictions in order to explore different qualities of the machine (e.g. its potential for empathy). It stands, therefore, in contrast to the well-functioning and predictably behaving robots that have mimicked the body down through the ages. From the rise of the Industrial Revolution to AI in the 1960s conventional presentations have defined the robot imaginary as either utopian or dystopian, and in both cases robots had qualities that surpassed those of the human being.

The way engineers and scientists present their robots to the general public has been analysed by Weber, who views these presentations critically as framed and edited, their real purpose being to show the machine's capabilities, either real or pretended (Weber 2007). The staging of these presentations offers stereotypical situations such as *Asimo* serving coffee and *Paro* being stroked by an enlightened elderly person. Science-fiction characters are also stereotypical of the omnipotently clever (the computer HAL in Kubrick's *Space Odyssey*) or the indestructible and mighty (the androids of the *Terminator* film series).

In the context of *La Cour*, I wish to elicit another side of the machine: its affective response. In her essay referred to above on "Artificial Life and Robots", Tenhaaf pinpoints the difference between scientific and artistic stances:

> Robots tend to foreground autonomous behaviours such as mobility and sensitivity to their environment and to mimic the sensory responses of humans or animals. However, A-Life robotic artworks are invariably different from robots found in research, even if they investigate many of the same questions about agency and artificial embodiment. Unlike research robots that are studied to gain quantifiable data, robotic artworks call attention to relationships between robots and humans, whether those humans are the creators of a work or members of the public. It is not simply a question of objective or subjective points of view; it is a question of the robotic artist wanting to elicit narrative elements and affective responses that complicate a viewer's response to the work. In the lab, those narratives may be present but are set aside. (Tenhaaf 2008)

Deliberately putting machines in a weak position in relation to the audience focuses attention on that relationship rather than on the functions of the machines. As Whitelaw discerns with respect to *La Cour*, the experience is not situated in the robot itself but in the interface of audience and robot, in the atmosphere created by the mise-en-scène: "*La Cour des Miracles* are other works that elicit empathy and flesh out a communicative exchange that is not controlled by either humans or artificial entities but lies in a space between the beings involved" (Whitelaw 2004, p. 214).

1.6. Contributing work: *The Blind Robot*

1.6.1. Description

With the *Blind Robot*, I aim to further understand the degrees of engagement, intellectual, emotional and physical, that are generated when a social robot touches a person intimately. In essence the *Blind Robot* is a piece of minimalistic mechanical engineering. The rationale is to start from a familiar cultural artefact, the robot arm, and transform it from a high-precision tool into a fragile, imprecise and emotionally loaded agent.

The *Blind Robot* comprises a typical robotic arm equipped with an articulated hand. In this installation, visitors are invited to sit in the front of the machine and engage in non-verbal dialogue with it. The robot delicately explores the body – mostly the face and upper body – of the visitor in a manner that recalls that of a blind person seeking to recognize another person or object. On a nearby monitor or projection screen the machine then produces a visual rendering of what its fingertips have "seen".

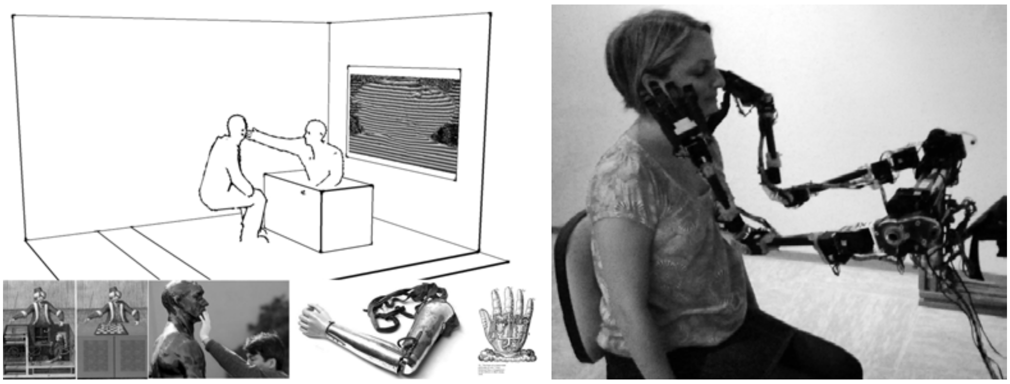

Figure 14. *The Blind Robot*. Concepts and mechanical incarnation (Demers 2012)

The hypothesis I set out to verify in this artwork is that the social role of the robot, simulating that of a blind person, will augment the merely physical act of touching via the potential of the created emotional connection between the human visitor and the robot. Only limited research has been devoted in social robotics to the sense of touch, and in particular to invasive touch to our vulnerable body parts: head, neck and torso (Chen, King et al. 2011). If the role of a social robot – in this instance modelled on the healthcare provider – is to be fully integrated into human society, these robots will have to go beyond non-invasive touch (handshake, patting) and address the complexities of human proxemics.

The *Blind Robot* then becomes an artistic and critical investigation of the scientific developments of social robotics with the following aims:

- To verify if the mise-en-scène of a social robot influences, shifts or augments the perception of the participant.
- To explore the impact of empathy from a suggested character on invasive touch and investigate if these circumstances modulate the perceived competency of the agent.
- To verify how faithful, precise or delicate the touch has to be in order to be accepted.
- To verify if the robot has to be verisimilar to a human for such intimate contact.
- To generate conditions where the *Blind Robot*'s touch would be accepted as a "feel-good" (Burwell 1999), potentially altering cultural preconditions and resistances.

1.6.2. Developing the Blind Robot

The development of the robot lasted over a period of twelve months with a team of two people. One staff member developed the arm architecture and the hand mechanism while the other was responsible for software control and mathematical models for forward and inverse kinematics of the arm. I supervised the whole development, staged the work and finalized the entire programming.

The proportions of the arms and hands were measured on my own body. The actual geometry – a straightforward six degrees of freedom manipulator – of the constructed limb is depicted in Figure 15. The original plan considered cosmetic draping of the skeleton in an attempt to recreate a similar aesthetic as that found in an 18th century device. At this stage, I did not have the occasion to try these designs and to measure their impact on the audience. However, I had to be careful with the payload of the arm; this needed to remain as lightweight as possible, and eventually ruled out enrobing the arms.

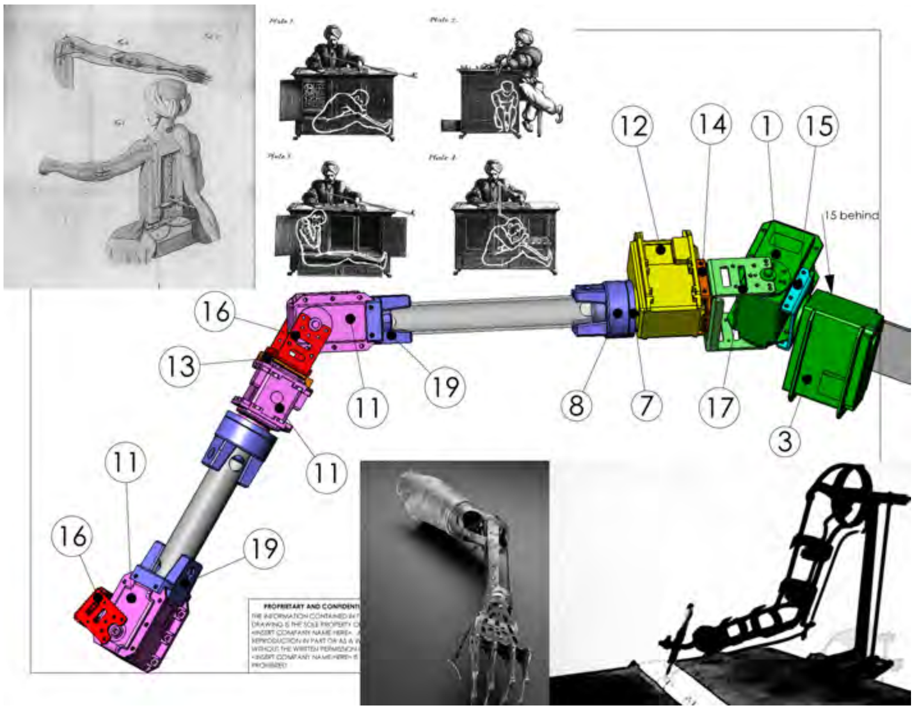

Figure 15. Geometry of the arm (Demers 2012)

The object of the design of the hand was to mechanically master a limited range of acceptable touches and sensations to be given to a viewer's body and face. I did not seek to reproduce a human hand's full flexibility or aesthetics. Inventorying the state-of-the-art robotic hands in current use, I quickly realised that gaining access to a high-end solution would be both costly and time-consuming. With my team, we designed the hand based on articulated mechanisms found in finger prostheses and decided to opt for lightweight plastic materials. The shell of the hand (its skin) was chosen to provide an agreeable sensation of touch while dissimulating its internal mechanism. As the main source of body interaction between the *Blind Robot* and the participant's skin are its fingertips, the robot needed to skilfully sense these contacts. We concentrated our design on the fingertips' acute sensing capabilities and the required miniaturisation of the pressure sensors (see Figure 16). Very complex attributes that are difficult to faithfully reproduce, such as skin temperature and texture, were not addressed by this project. The aesthetics were intentionally mechanistic, as was the range of touch and movement, yet performed with a necessary amount of care and sensibility to maintain affinity in the contact.

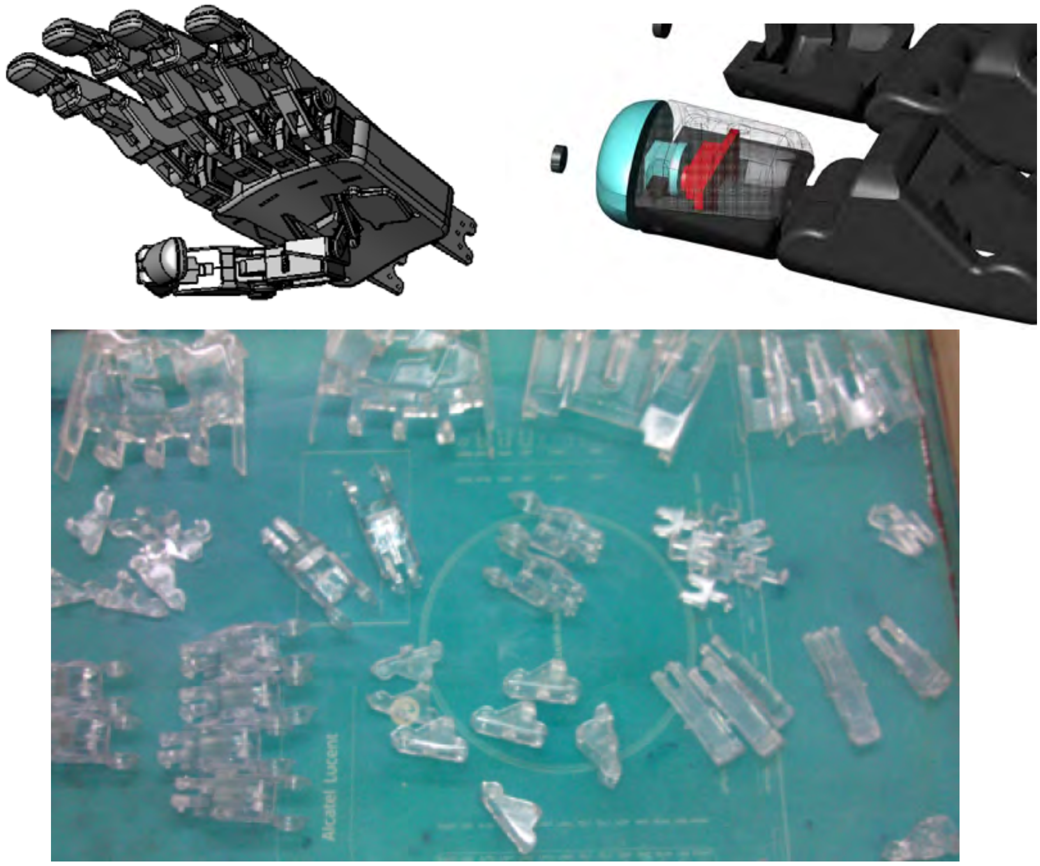

Figure 16. CAD model of the hand, fingertip sensor and CNC parts (Demers 2012)

Ultimately and intentionally, the *Blind Robot* was constructed with relatively low-end robotic components. However, this choice led to an accumulation of feedback errors that made fully automated computer control of the arm a nearly impossible task. Moreover, an algorithm that will find and recognize the body parts of a person simply by means of touching is a great challenge. I could design methods that would make the arms scan the space and progressively discover the shape of the body in front of it, but this also needed precise feedback systems. Facing this challenging task, I decided to opt for a tele-operation scheme, where most of the movements of the *Blind Robot* were under human supervision (see Figure 17). The finger motions are on an automated feedback loop to minimize the actions required by the operator, while the control information for the arms is intuitively captured by remotely manipulating a facsimile of the arms. Nonetheless, I am planning to develop an automated version of the *Blind Robot* that will require external and accurate sensors to measure the positions of the various articulations of the arms and hands.

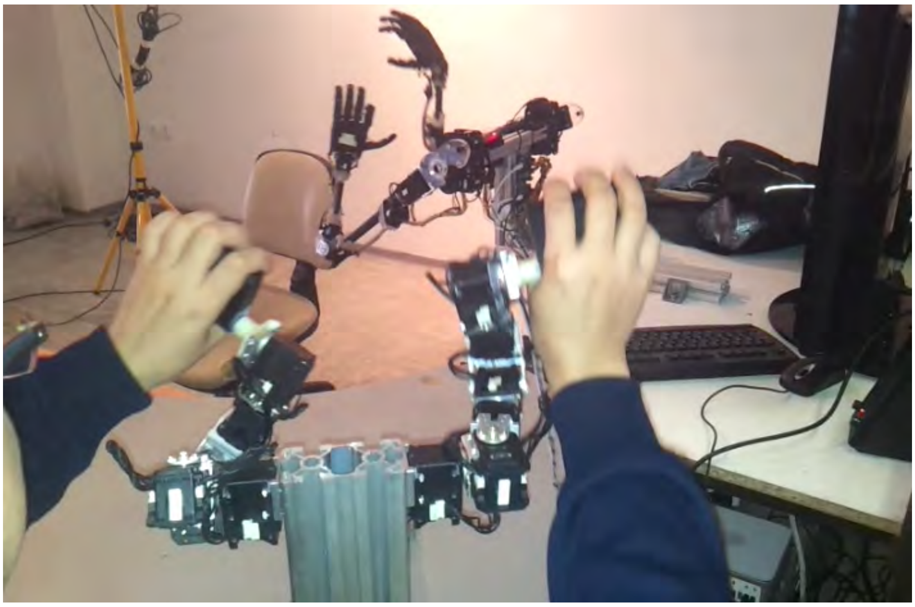

Figure 17. Tele-operation. The robot arms extend the operator's gestures (Demers 2012)

This technical decision introduced another facet to the project; it created a scenario similar to Kempelen's *Chess Player*. In this way, the *Blind Robot* not only investigates the impact of the empathic character of the agent but investigates the perception of its borrowed competence. In Chapter 3, where I compare embodiments, I will cover a quantitative experiment, a sort of Turing test that I performed with the *Blind Robot*. For the purposes of the present section, I will analyse the *Blind Robot* along the same vein as *La Cour des Miracles*, based on observations gathered during the public presentation of the work.

1.6.3. Presentations and data gathering

The *Blind Robot* premiered at Kibla (Maribor, Slovenia) as part of the European Capital of Culture programme in 2012. Kibla programmed the exhibition with the British association Robots & Avatars which had originally commissioned the *Blind Robot*. In the course of the exhibition I gathered video footage of visitors (n=12), informal discussions during the opening event, and ad-hoc comments during testing phases of the robot.

During the exhibition, the operator of the robot was hidden behind a one-way mirror window while gallery goers could watch people experiencing the *Blind Robot*.

Figure 18. Visitors and *Blind Robot* (Demers 2012)

1.6.4. Embodiment and staging in the Blind Robot

Many media artists put physicality and tactility at the centre of their research and practice. Early tangible works like Fleishmann's *Liquid Views* (1994), Schiphorst's *Bodymaps: artefacts of touch* (1995) and Dubois' *Les Errances de l'Echo* (2004) establish touch as the modality of interaction. In social robotics, touch is at a very early stage. So far, touch has been mainly limited to non-vulnerable body parts and non-invasive gestures such as handshakes or hugs. Furthermore, social robots as toy companions focus more on the sensing side than on the affective side of touching (Velonaki, Rye et al. 2010).

Heslin describes five types of touch according to their functions: functional/professional, social/polite, friendship/warmth, love/intimacy and sexual arousal (Heslin 1974). His research demonstrates that the interpretation of a specific touch is affected by factors such as: the modality of the touch (pat, squeeze, stroke, poke, etc.), its location, duration, intensity and frequency. Gender and degree of interpersonal involvement between the two people concerned are also factors. The location of touch can be divided into "non-vulnerable" and "vulnerable" body parts. For instance, hands, arms and shoulders are considered non-vulnerable, while head, neck and torso are seen as vulnerable. To sum up, a touch that invades our privacy has the potential of being perceived as less positive (Burwell 1999). Modulating intensity and duration will associate anger, love, gratitude or sympathy. Sympathy may be associated with a long duration but moderate touch, anger with a strong touch of moderate duration, and gratitude with a handshake.

The *Blind Robot* creates a specific context for the participant: touching a face is a very intrusive and intimate action and the *Blind Robot* walks the thin line between being a cold stranger and an empathic agent. To analyse its acceptance, I will show the following:

- As an artistic strategy, presenting a **competent** machine that targets very minute and precise human activities (touching) helps to reinforce notions of **embodiment.**
- The *Blind Robot* reflects on an **historical** situation by recreating the **staging** of the *Chess Player*.
- By **amplifying** the stereotyped situations (social robots as friendly agents) found in scientific **presentations**, the *Blind Robot* engenders an artistic scenario through its mise-en-scène.

1) Competence and embodiment.

The *Blind Robot* is a direct reference to the works of Merleau-Ponty and his example of a blind's man cane becoming an extension of the body. The blind man senses the world through the cane; he is not directly conscious of the cane as such but rather of what it touches. The cane becomes incorporated in the body scheme of the blind person and acts as an extended sense organ. As Merleau-Ponty claims: "To get used to a hat, a car or a stick is to be transplanted into them, or conversely, to incorporate them into the bulk of our own body. Habit expresses our power of dilating our being in the world […]" (Merleau-Ponty 1962, p. 143).

When Feenberg analyses Merleau-Ponty's blind man's cane, he concludes that the cane does more than sense the world; it also reveals the blind man as blind:

> His body is extended not only in the active dimension on which Ihde and Merleau-Ponty focus but also in the passive dimension of its own objectivity. Those around him recognize his blindness and are generally helpful. The blind man knows this is happening and has a non-specific awareness of the helpfulness of those who perceive him as blind because of his cane. (Feenberg 2003, p. 105)

It is this very aspect that the *Blind Robot* seeks to exploit: to create an empathic situation and a positive predisposition for engagement. It is not concerned with the aspect of use (technicality of touch itself) but rather with the consequences for bodily objectivity and the subject's awareness of those consequences. It aims to exploit this passive dimension and to explore its repercussions in the acceptance of the robot's very invasive touch. The *Blind Robot* is endowed with an arm and hand to sense its environment: the embodied "cane" of the computer dialoguing with the viewer. The robot's gestures and the environment reveal it as blind.

In *Agency and Embodiment*, French literature professor Noland (Noland 2009) discusses agency through "tatonnement"[13] in opposition to haphazard discovery. "Tatonnement" has a double meaning in French: it refers to the groping movements of the hands but also indicates an intellectual process of testing out possible solutions. "Tatonnenement" could also imply the use of a prosthesis (a blind man's cane for instance). "Tatonner" conveys a sense of exploration, whether physical or cognitive.

These "tatonnements" are hints that the Blind Robot will be gentle rather than invasive, but they are also indications of a heightened potential for sensuous arousal in the visitor. In a reversal of roles, I have observed that the object becomes the subject in this gestural interchange. I would then extend the following statement of Noland: "Inchoate groping transforms the body into a receptor or, better yet, encourages a heightened attention to the sensory information that is always potentially available to a body that is skin and nerve and not plastic or metal" (p. 105). In our case, the receptors are both subject and object. Visitors become focused on this non-human touch while witnessing the Blind Robot's groping heuristics unfolding on their body: the subject becomes the heightened site of reception.

13 Noland bases her analysis on Leroi-Gourhan's notion of "tatonnement" in gesture and speech.

When Noland links Derrida's *Memoirs of the Blind* – "a hand feels its way, it gropes, it caresses as much as it inscribes" – with "tatonnements", she looks at the semiotic and instrumental orders of the gesture and how they are mutable and plurifunctional:

> The locution suggests further that the body performing inscriptive gestures is more than instrumental or expressive, spectacular or sentient; the body engaged in the gestures of writing is exploratory as well. Caressing the space of inscription is one way for the body to orient itself in, parse, and divide up space by means of self-displacing "tatonnements". (p. 209)

Gestures of groping (for a blind person) or writing are techniques of the body, constructed syntactic sequences executed with the intention to discover/fabricate an object, leave a mark, or accomplish a task. Being touched by the *Blind Robot* is, therefore, more than just the instrumental action of groping; it is the whole situation of a shared habitus, technical intentionality and social inscription.

2) Staging.

In the *Blind Robot*, I did not employ saturation of the senses as in *La Cour des Miracles*. The lighting revealed everything; the sound was only to clothe the space with a texture and also to provide an acoustic feedback when the robot touched the person.

The *Blind Robot* is a direct allusion to Kempelen's Turkish *Chess Player*. The set-up is similar, with a mechanical upper torso representing the human body. The Chess Player engaged in a sophisticated mental activity while the Blind Robot engages in an intricate physical activity. Both situations call for a high-level of competence from the agent that in turn, raises scepticism about true nature of the situation.

The visitor is invited to sit in front of the robot, a position similar to that of a game of chess. The swindle is that – as in the *Chess Player* – the robot is under human control and the perceived behaviours of the Blind Robot emanate more from a make-belief in the scenario than from the actual capabilities of the machine (Sussman 1999). The human operator is not visible, and Blind Robot's hands appear to be able to find body parts and touch them automatically.

However, the *Blind Robot*'s structure and constituents are directly exposed and there is no attempt to conceal the nature of the object. The movements are deliberately presented as issuing from the mechanical realm; what is concealed is only the competence of the robot to touch the visitor. As I was able to observe during the opening event, nobody seemed to care about the veracity of the animation of the object, whether it was a complex AI system, a marvel of bio-mimicry, or simply a brutally imposed hoax. The staging of the experience and of the atmosphere seemed to be at the forefront of the audience's concerns.

3) Amplification

The *Blind Robot* negates the a priori perception of mechanical touch. After the initial contact (discovery), participants engaged playfully and trustingly with being touched by the robot. Visitors accepted the *Blind Robot*'s exploration, recognized as gentle and less invasive. Sometimes the visitors led the robot in the movement (joining hands) and sometimes she or he waited to discover the "new" sensation of being explored by a robot (mostly on the face).

The surprising reactions of visitors to the touch and groping of the *Blind Robot* also indicate that veracity and verisimilitude to human touch are not central to the experience. The quality of the touch is actually amplified by the staging of the situation, the uniqueness of the experience and the acceptance of the touch as being singular to the blindness of the robot. The technicalities of the mechanism did not seem to impact the audience. Even when some of the finger movements were not operational, visitors were still very much in tune with the experience of being touched by a non-living agent.

I received a few questions about the underlying mechanisms involved in animating the robot arms and hands. Actually, only a few people, technically versed, asked me how the robot was able to perform such complex gestures. I admitted that this was a hoax and their deception was more about the functionality of the system than about the experience they had: revealing the trick did not seem to cancel or drastically alter the experience for these viewers. Overall, the concealment of the tele-operator did not seem to impact the audience's judgment of the *Blind Robot*.

If I compare this scenario to Ishiguro's *Geminoid* presentations, there is quite a shift in audience reaction[14]. *Geminoid* and *Blind Robot* share anatomically correct representations of the human body and both are remotely operated. With *Geminoid*, the audience is captivated with finding visual and tactile cues (hair or skin textures, water in the eyes) and deciphering and registering any minute moves. *Blind Robot* is, in contrast, raw; its anthropomorphic arms serve the purpose of groping, their verisimilitude is found in the groping action, the fictional situation of the blindness of the agent and not the skin texture becomes the fascination point for the audience.

The focus of the experience is the hands of the *Blind Robot*, more specifically the vicinity of the points of contact of the two bodies. The dance of the hands in space onto your body is a singular experience, neither human nor mechanical. The hands are the residual body of the agent touching the visitor; engaging with the sensuality of the experience, visitors try to integrate these new sensations.

Belief in this case does not focus on the endowment of the robot with intelligence but instead on its ability to touch and explore your body with delicate precision and care. The actual suspension of disbelief is that the *Blind Robot* will touch you softly and engage in bodily dialogue with you. Participants do not seem to compare or measure the realism of the motion of the arms/hands with the human. They accept the artefact at face value as a mechanical construct. They amplify this animated robot in order to focus on the animate experience of having their own body touched.

14 I attended Ishiguro's demonstration at Ars Electronica 2009. Further details about this experience are presented in section 2.3.

1.7. Conclusion

In Mulder's examination of Lewis Mumford's critique of the idea of the body as a machine (Mumford 1934), he accurately isolates the attitude of modern natural science:

> Like the monk the exact scientist sees the world as spiritless, as purely matter, factual and therefore measurable. The scientist, like the monk, positions himself outside the world, where he overlooks and looks down on life. The scientist also thinks that intuition and other animal cognitive tools are irrelevant to his task as only the mental faculties of man are capable of fully understanding the laws that nature and the mind obey. Mumford: "Machines – and machines alone – completely met the requirements of the new scientific method and point of view: they fulfilled the definition of "reality" far more perfectly than living organisms." For man to be able to live with a scientific worldview he must turn himself into a machine. (Mulder, Post et al. 2000, p. 12)

In Mulder's view, we are still permeated by a scientific view of the body that is predominantly derived from a mechanist perspective. While engineers are concerned with realism and characteristics that make a robot "perform" in the humanly built environment at large, the present research is concerned with the specific issue of how to make a robot "perform" for the stage framed by a context or a mise-en-scène. The *machine performers* that I develop do not attempt to duplicate human performers; my works are rather experiments in audience reception. My explorations into alternative body morphologies for *machine performers* provide new insights and guidelines on their design rather than solving intricacies of their inner body (or the human body). These insights aim to help *machine performers* navigate the thin line of the animate-animated equation.

Nowadays, Mumford's observation resonates without equivocation: the robotics (and particularly social robotics) community claims that through the construction of machines that mimic the social human we will be able to understand and model the (ideal) human. This presupposes that there will be equivalences (at all levels) between the organic human and its sensorimotor counterpart. These equivalences raise direct reminiscences of the cybernetic view of living organisms (biology). Today, I think, these mechanistic and cybernetic models are far too limiting, because they do not account for a history of adaptation and transformation based on learning and memory found in the human body.

Kaplan observes that the robot body is at the same time similar and different from the human body (Kaplan and Oudeyer 2008). He is more modest in his approach to investigating complex constructions such as androids. What he suggests instead is to explore “invented” bodies, thus implicitly considering the body as an experimental variable. In accordance with this assumption, my work looks into similarities, complementarities and differences between the *machine performer* and the human body (audience). For alternative morphologies to enhance *machine performers*, I consider that they need to encompass the 1960s cybernetic anthropocentric shift, as well as implementing a tighter coupling between their bodies and their animations.

Explorations into alternative body morphologies can, in turn, provide new insights for embodied robotics. The stage is a “controlled” environment and I consider it as my laboratory for experiments on the embodiment of *machine performers*. By extension, I do not limit myself to the stage as a proscenium but to any space where a mise-en-scène can take place. In this sense, an installation is to be equally considered as a stage from the perspective of its mise-en-scène of the agents.

The perception of a robot’s behaviour goes far beyond the reality of its sensorimotor behaviours and embarks into the areas of fakery and mystification. Robot history brings us numerous scenarios where the situation obscures, conceals or augments the actual capacities of the agent. In *La Cour des Miracles*, viewers experience the *machine performers* as entities experiencing bodily pain, not solely as robots mechanically reproducing signs of pain. By encompassing many layers of embodiment, from the physiological to the social, *La Cour des Miracles* enhances viewers’ own bodily reception and encourages them to see these machine characters not as tools to show pain but as bodies that actually experience pain. The empathy is with the perceived behaviours of the robot, not with what their bodies look like. The behaviours are implemented by sets of movements, hints and assemblages that are culturally coded (beggar rocking, rebel/heretic shaking the cage), socially coded (harassing) and bodily coded (the motoric sensation of spasms).

In the *Blind Robot*, the novel phenomenon of being touched by a robot enables the audience to engage in a sensual experience, as opposed to one of solving the intellectual, ontological issues of the quasi-living. This scenario demonstrates some of Merleau-Ponty’s phenomenological statements: “attention to life is the awareness we experience of 'nascent movements' in our bodies" (Merleau-Ponty 1962,pp. 90-91). My research into embodiment expects my audiences to be active witnesses of these experiments. As an A-Life art exploration, studying the embodiment of *machine performers* also contributes to the scientific field. As argued by Tenhaaf:

> The A-Life research community has become interested in A-Life artists over the past few decades precisely because of their deployment of research concepts in public space. Their artworks call attention to the role of the "participant subject" and invite the recognition that one of those subjects is the researcher her- or himself—albeit an expert one rather than a novice. A-Life artworks can explicitly explore the boundary between the researcher and the subjects of the experiment: "This researcher will have to allow for—perhaps even explore— other emotions than those of the ideal distanced witness". This kind of shift in thinking, and the exchange of interests and working methods in general, continues to be one of the most fruitful areas of art and science crossover.[15]

The dichotomy in the impact of embodiment in robots is symbolized by the old and new AI approaches. I see this as powerfully mirrored in the current disciplines of androids and bio-mimicry. Exploring alternate morphologies is a path to "reconcile" these avenues:

> No doubt we must get beyond the anthropological in order to reckon with the Merkmale of our irrevocably displaced humanity and to see that machines which centuries ago began to move away from the human they used to simulate are now coming to seek the soul they had forgotten. […] The imaginative rationality (Lakoff/Johnson) in the arts offers a unique way of structuring and integrating conceptual frameworks thereby producing an "autonomous kind of thought", which allows the emergence and recognition of new Merkwelten. (Norman 2012)

In this chapter, I have exposed the ongoing dialectic between man and machine and between the natural and the artificial. It is not surprising that nowadays we are witnessing a plethora of attempts to unify these opposites. So far I have spoken of embodiment without introducing phenomenology. I would like to conclude this chapter by presenting phenomenology as a methodology and framework for analysing, designing and staging *machine performers*. For, as demonstrated by the shifting barrier of the animal and the machine, the different epistemes issued by different models of the body do change our perception of the mimesis of *machine performers*.

In philosophy, phenomenology explores aspects of being in the world, dealing with the liminal divide between the body and its surroundings, between subjectivity and intersubjectivity. Merlau-Ponty points out that our bodies are not in space but of

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15 Part of the press release of *Art and Artificial Life, The retrospective of 10 years of VIDA International Awards*, 2012.

space, constantly integrating objects into our bodily space or being projected out of our bodily space (Merleau-Ponty 1962). Phenomenological discourse has reached many fields, including theatre as an alternative analysis to semiotics. The theatre is uniquely able to illuminate the stage's experiential duality, and Garner (Garner 1994) considers that the stage is simultaneously objectified (a detachment) and subjectified (the co-presence of actors).

The next chapter will investigate the dissonance of a misalignment between the movements and appearance of the robotic body, a potential phenomenon of rejection impacting *machine performers*. The Uncanny Valley is a thesis that relates the level of anthropomorphism of a robot and the affinity it engenders in its relationship with the human. In Chapter 3, I will then present various layers of embodiment found in phenomenology to contrast them with the notions of embodiment found in nouvelle AI. This chapter will look at the *machine performer*'s body from within, while Chapter 4 presents the view from the outside, the human phenomenological perception of *machine performers*.

2
The Uncertain Valley

2.1. Outline of chapter

This chapter aims to capture some key ideas in the current discussion of the Uncanny Valley, a phenomenon and a body of theory concerned with the unexpectedly negative reaction of humans to near-human robots. As demonstrated in the previous chapter, the topic of devices that mimic the human form is far from recent. Hence the Uncanny Valley takes its place within the historical lineage of robots, a tradition that plays a considerable role in the current understanding of the human body and is a social reflection of our era. In an age of omnipresent replication (nanotechnology, increased realism from technology), genetics (biology and cloning) and posthumans (one of the world's fastest runners has prostheses instead of legs), androids and geminoids (aka second life) resonate with current concerns. From the engineering and scientific standpoint, the Uncanny Valley is an icon of the current state of human representation, embodiment and artificial intelligence.

The reasons why the Uncanny Valley is heavily featured in this dissertation are numerous. The discussion has created a controversy not only in science but also in the arts. Automatons and animatronic figures have been around for a long time in the entertainment industry. In order to situate my approach to *machine performers*, and in opposition to current modes of casting androids/actroids, this chapter will look into the impact of their verisimilitude in the performing arts and everyday life. Does the supposed Uncanny Valley – the asymptotical burden in the acceptance of humanoid robots – also hold for *machine performers* on stage? By investigating artistic counterparts to the Uncanny Valley, I will show that the hypothesis can be reformulated in embodiment terms, applicable to the stage, the arts and social robots.

I will first look at the original definition of the Uncanny Valley thesis and point out some key elements – such as escape by design – left aside by the current literature. As the formulation of the thesis calls upon parameters such as anthropomorphism and affinity, the still open question of measuring these will be addressed. Following this, I will undertake a comparative analysis to highlight various angles of research into the Uncanny Valley. Two polarized schools of thought have emerged in the field of social robotics: researchers into humanoid robots are trying to bridge the gap between reality and fiction, while researchers into non-humanoid robots are optimizing design within the niches of specific robotic applications.

I will then further investigate why and how the Uncanny Valley seems to be a greater problem in science than in the artistic world. First, I will demonstrate the acceptance and empowerment of the Uncanny in the artistic world and how it might constitute an aesthetic value of its own (Kozin 2006). Secondly, I will compare alternative formulations of the Uncanny Valley hypothesis and similar perceptual ambivalences and adapt these to the case of *machine performers*. These formulations are the concepts of *multistability* from theatre performance theorist Erika Fischer-Lichte (Fischer-Lichte 2004; Fischer-Lichte 2008), of *ambivalent power* from art historian Minsoon Kang (Kang 2009; Kang 2011), of *two to ten seconds of confusion* from robotic artist Zaven Paré (Paré and Grimaud 2011), of *empathy and imaginative perception* from philosopher Catrin Misselhorn (Misselhorn 2009; Misselhorn 2010), and of *Heider's balance theory* from psychologist Bardou and roboticist Tondu (Tondu and Bardou 2011). Thirdly, by bringing the robot into the arts realm and away from the laboratory, I will show how these shifts in perception affect the Uncanny Valley. Via case studies and one of my own practical works (*Area V5*) I will demonstrate that the acceptance of potentially uncanny agents can be mediated.

In adapting the Uncanny Valley to quasi-living machine performers (sometimes non-anthropomorphic) I aim to bridge the notions of embodiment found in performance theory and robotics. In recent analyses of theatre (Power 2008), for instance, *presence* is a key element qualifying the intangible perception of acting bodies on the stage, and this, after all, is what the Uncanny Valley expresses for a very specific narrative. The Uncanny Valley calls upon shifting and evolving perceptions on the part of the viewer. Given the differences and similarities between scientific and artistic issues, I claim that art, particularly the *machine performer*, is able to re-situate and re-appropriate the perceptual and conceptual issues of the Uncanny Valley. I am, in fact, looking at what constitutes a breach in the suspension of disbelief in the case of the machine performer, and investigating whether phenomena surrounding the Uncanny Valley can participate in this breach.

2.2. Mori's Definition

2.2.1. The Thesis

The Uncanny Valley thesis was first presented in 1970 by Japanese roboticist Dr. Masahiro Mori (Mori 1970). In the wake of continuous interest from roboticists and engineers, Mori recently republished an updated and "authorized" version of his 1970s publications (Mori, Macdorman et al. 2012). Though the essence of the thesis is mostly conveyed by plotted graphs depicting human responses (affinity) towards the verisimilitude of a robot, Mori's published texts do not include any "formula" per se. The closest he provides to an algebraic formulation explaining the curve of the graphs (see Figure 19) is qualitative and metaphoric rather than quantitative. Mori contextualizes his Uncanny Valley graph in contrast to monotonically increasing functions, or as reformulated by psychologist Frank Pollick:

> An example of a function that does not increase continuously is climbing a mountain—the relation between the distance (x) traveled by a hiker toward the summit and the hiker's altitude (y)—owing to the intervening hills and valleys. I have noticed that, in climbing toward the goal of making robots appear like a human, our affinity for them increases until we come to a valley (see Figure), which I call the uncanny valley. (Mori, Macdorman et al. 2012, p. 98).

In an earlier publication Pollick puts the issue of the Valley very succinctly:

> Assume we could make a robot more and more similar to a human in form, would the affinity to this robot steadily increase as realism increased or would there be dips in the relationship between affinity and realism? (Pollick 2010)

Mori's thesis proposes that there will be a strong negative dip in the form of the Valley. First there will be an increase in perceived affinity, but as the robot approaches a nearly human state, acceptance will dramatically decrease. Mori plotted his assertion as a function f(x) – a two dimensional graph – showing strong aversion when the robot is near-human and growing back towards affinity when the robot is virtually human.

Mori coined this precipitous drop in Japanese as "bukimi no tani". The term Uncanny Valley surfaced only later as a translation and was popularized in the literature on the subject. "Bukimi" has several translations into English: "eerie", "strange" and "uncanny". It is speculated that "uncanny" was chosen because of its resonance with Freud's 1919 essay "Das Unheimliche", later translated into English as "The Uncanny" (Freud 1960). Reichardt (1978) was probably among the first to popularize the term "Uncanny Valley" in her seminal book *Robots: Fact, Fiction and Prediction*, which contextualized the concept, as the title suggests, within the vast array of human imitations of the body by robots.

The Uncanny Valley has recently evoked growing interest in the milieu of robotics, especially in the fields of social robotics and artificial intelligence. Even though the term was coined more than four decades ago, it has recently emerged at the centre of discussions about physical humanoids and virtual human characters[16], and it continues to generate a fair amount of debate and even dissent within the robotics community.

This section of my research, however, is based on an investigation of prior attempts to formalize human mechanisms regarding the acceptance or rejection of robots as credible agents. For, although not yet precisely formulated, the Uncanny Valley thesis collates a body of evidence concerned with levels of quality in anthropomorphism and movement, and the associated discussion has produced

[16] Its focus on human replication inevitably limits its morphological scope with respect to the broader category of machine performers.

formulations and methods of comparing robots within these perspectives. Thus the Uncanny Valley has been used to describe robot design process (Dautenhahn 2002), to justify a robot design (DiSalvo, Gemperle et al. 2002), and to formulate hypotheses when conducting psychological experiments into human reactions to robots (Gee, Browne et al. 2005).

2.2.2. *The graph and its interpretation*

The Uncanny Valley is usually visualized in the form of an iconic graph plotting Mori's thesis. Figure 19 illustrates its most common depiction. The vertical axis plots perceived affinity towards the agent from negative to positive. The horizontal axis charts the level of anthropomorphism – i.e. of similarity to the human.

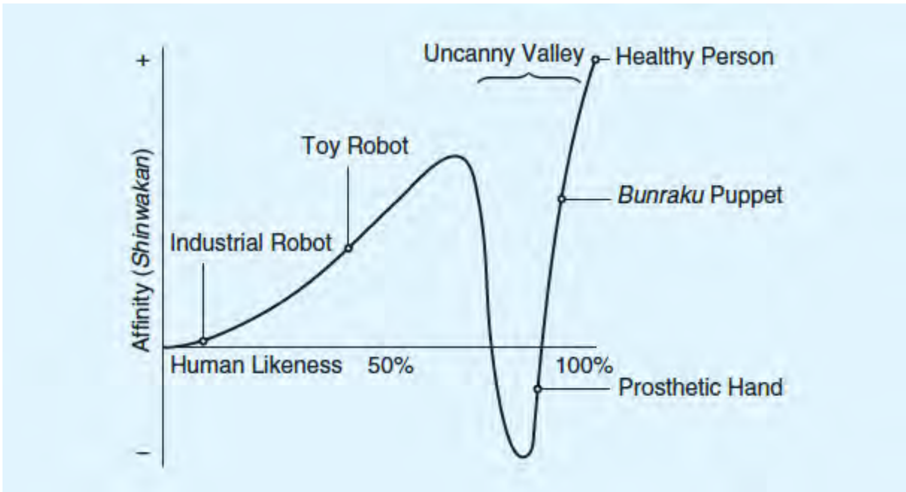

Figure 19. The Uncanny Valley graph
Permission to reproduce this image has been granted by IEEE.

In order to travel the graph and its axes, most literature on the subject places robot instances at relevant points (Fong, Nourbakhsh et al. 2003), indicating – generally on the basis of empirical assessments and folk psychology (Dennett 1987) – that the anthropomorphism scale can go from industrial robot to toys and ultimately to a carbon copy of the human. Alternatively, utilizing abstract icons, a character can progress from a pure geometrical shape through an iconic form such as a smiley face to a cartoon figure.

Mori takes account of the joint impact of movement and appearance in his thesis and states that it shapes the graph by amplifying the peaks and valleys. He suggests that anthropomorphism emanating from movement has a stronger impact than that based on appearance. This observation is further corroborated by psychological studies of the perception of movement and animacy. In Chapter 4, I will examine the surprising results of Heider and Simmel's experiments, where abstract geometrical shapes are vested with human behaviours solely by their movements (Heider and Simmel 1944). However, such experiments are difficult to represent on Mori's graphs, as they evade his method of plotting the situation. Movement (not shape) is the anthropomorphic evaluation here, and the introduction of simple shapes would cause a strong misalignment between appearance and movement plots.

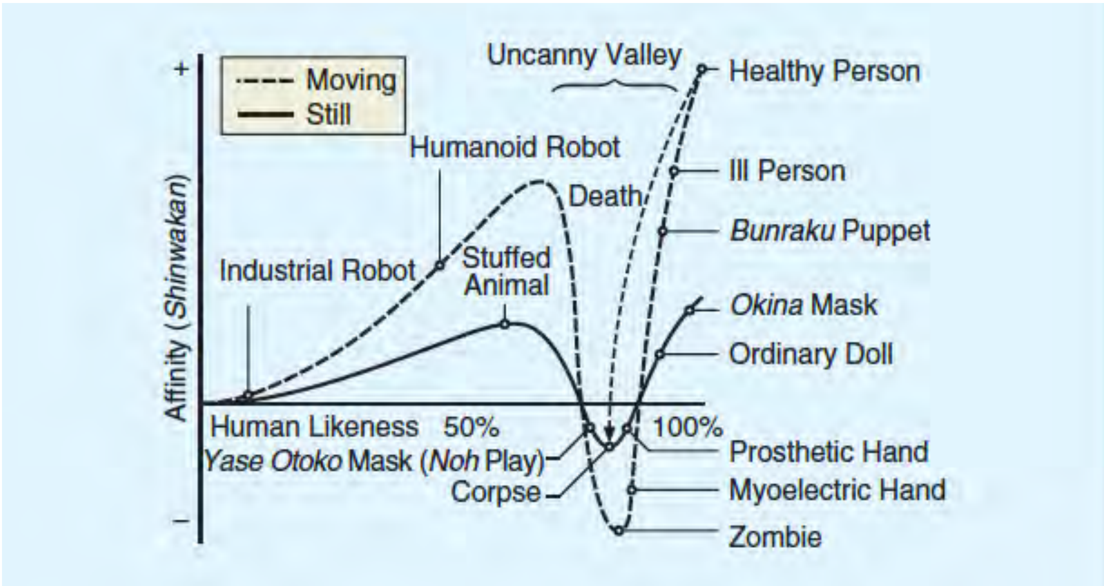

Figure 20. Movement versus appearance graphs
Permission to reproduce this image has been granted by IEEE.

Figure 20 shows two overlaid graphs. The dotted line shows the response curve for a moving robotic agent. In the original paper Mori states that with industrial robots the impact of movement is relatively low, because we see it as a functional machine. He draws a clear line between opposite characteristics – either agentic or automatic (the animate vs. the animated, the intentional vs. the functional) – in the perception of behaviours in self-propelled machines. In this thesis I will argue from various perspectives that this agency stance is pivotal in the credibility and acceptance of machine performers.

Mori's hypothesis reflects the "form vs. function" design paradigm, inasmuch as specific kinds of agency pull "form vs. function" in one direction or the other (Dautenhahn 2002). Thus industrial robots are task-oriented and their shape is derived from their function. On the other hand, a robotic toy needs to pay attention to its shape in order to trigger affection. The humanoid quest pulls both form and function towards the human spectrum.

Rather than strictly addressing humanoids, Mori's original publication targets issues in the design of what would later be called social robots. Actually, Mori focuses more on visual cues and movements of robots involved in human-robot interaction than on their mimicry of humans. He suggests escaping the technological challenge of the Uncanny Valley by design – a strategy later referred to as "escape by design":

> We hope to design and build robots and prosthetic hands that will not fall into the uncanny valley. Thus, because of the risk inherent in trying to increase their degree of human likeness to scale the second peak, I recommend that designers instead take the first peak as their goal, which results in a moderate degree of human likeness and a considerable sense of affinity. In fact, I predict that it is possible to create a safe level of affinity by deliberately pursuing a nonhuman design. I ask designers to ponder this. […] As another example, consider this model of a human hand created by a woodcarver who sculpts statues of Buddhas […]. The fingers bend freely at the joints. The hand lacks fingerprints, and it retains the natural color of the wood, but its roundness and beautiful curves do not elicit any eerie sensation. Perhaps this wooden hand could also serve as a reference for design. (Mori, Macdorman et al. 2012, p. 100)

In a recent interview, Mori even questions the risk of attempting to cross the valley. From his perspective it is not even interesting to develop a robot that looks human (Kageki 2012). It is not surprising, therefore, that he uses the Bunraku puppet as an important example and puts it on the other side of the valley along with human figures. Mori sees the puppet as less realistic than a realistic prosthetic hand, as the puppet's appearance is not like that of a human being. However, at a certain distance the audience forgets the puppet's specific features, and its impact (appearance of eyes, hand movements etc.) more closely approximates the human. To the extent that an audience becomes absorbed in this art form, Mori concludes, it might feel a high level of affinity for the puppet.

The strategies of escape by design – and certainly the impact of art and staging – are not often mentioned in the scientific and engineering literature of the Uncanny Valley. Looking back at the history of robots, the Uncanny Valley feels like the ultimate test of verisimilitude, only accessible to a few initiated experimenters. While we are constantly breaking ground in psychology, biology, neurobiology and artificial intelligence, opening new horizons in the understanding of our bodies, we revert to primordial reflexes of belief in the ever-liminal man-machine relation. Here robotics has found its own quest: while physics looks for the all-unifying theory, robotics wants to find the secret of life in the form of a perfect model – which presumes a perfect understanding – of the human.

2.3. Scientific, Cultural and Artistic Stances

While Mori's thesis presents an asymptotic burden for roboticists to build humanoid machines, it contributes to the process and production of art by transforming the ambivalent state of the uncanny into an aesthetic experience with the potential to engage audiences. In this section I will contrast some artistic and scientific stances on the uncanny, reporting relevant contentions within the scientific world, presenting artistic strategies and comparing works from the two different cultures.

2.3.1. Robotic and Social Stances

Within the robotic community the Uncanny Valley thesis remains controversial. While there is some evidence for the phenomenon, critics have sound reasons to question its formulation. An inquiry into the intention behind humanoid research may shed light on dissident views of Mori's thesis.

1) Psychology of the phenomenon

Scrutinizing the formal aspects of the Uncanny Valley as a psychologist, Ramey infers that some people experience the effect while others do not. But in this case, if the uncanny does not exist, one must account for it in terms of a mistaken experience (Ramey 2005, p. 9).

Pollick puts forward a series of psychological plausibilities (Pollick 2010). He claims that, given the flow of correct perceptual information elicited by the humanoid in motion, small errors should be drowned out. If these small errors still surface, there must be a peculiar sensitivity to incorrect data on the part of the perceiving subject. He relates this to the human binary categorization process (Ramey 2005), as well as to cognitive dissonance emanating from the inability to categorize. He then looks into an existing case where motion exacerbates an uncanny situation. His assertion is based on the wealth of sensory cues and the process of reconciling them. Form and motion, for example, may contain different cues, and in their initial process follow separate visual pathways that are later integrated (Giese and Poggio 2003). Finally, Pollick introduces the social dimension, suggesting that the Uncanny Valley might not be an issue either of logic or of the confusion of perceptual cues, but rather of how the social brain evaluates these cognitive scenarios.

The human nervous system is innately and finely attuned to read the visual language of the human face (Levenson et al. 1990, Bruce et al. 2002), and this could elicit a stronger sense of affinity as the level of anthropomorphism increases. However, evidence from Heider & Simmel clearly shows that the opposite end of the anthropomorphic spectrum (abstract geometric figures) can equally trigger strong intentions and behaviours.

Many researchers speculate about the root of the uncanny feeling elicited by the robotic double. The literature often invokes the binary categorization of the human within the structure of reality/unreality and the perceptual uncertainty of the mind stuck at the bottom of the Uncanny Valley. Roboticists often cite Freud and formulate psychological reasons to explain their findings instead of leaving us with a simpler explanation based on dissonance or uncertainty. They cite emotions associated with the liminal divide of mortality evoked by the salient features of these robots (MacDorman 2005), look at corpses and proximal versus distal sources of danger (Mori, Macdorman et al. 2012), and consider the threat to the reality scheme inherent in dead things acting as if they were not dead (Kang 2009). And, of course, they cite Freud and Jenstch, bringing in Hoffman's Sandman along with anxieties of castration, childhood trauma and so forth.

In *The Freudian Robot*, humanities scholar Lydia Liu revisits Jentsch and Freud's arguments about the uncanny and their divergent interpretations of the intellectual uncertainty and anxiety this provokes when confronted with the animate/inanimate (Liu 2011). Jentsch – in his analysis of Hoffman's "Sandman" – not Freud, was the first to link the uncanny to automata, but Freud found the uncertainty too obvious and irrelevant for other striking instances of uncanniness. As the identity of Olympia is gradually revealed in Hoffman's story, Freud introduces an alternative explanation by displacing the automaton problem to the ocular anxiety of Nathanael (who had fallen madly in love with Olympia). He develops a parallel narrative based on a psychoanalytic standpoint, stressing that these anxieties render the intellectual uncertainty explanation irrelevant. Liu points out that most people are content to mimic Freud's manner of introducing the argument through etymology: the uncanny is the canny (i.e. known, familiar – from Anglo-Scots "ken" and German "kennen" = "to know, to recognize") in a concealed form (Liu 2011).

2) Problems of basic formulation

How can we precisely characterize the dimensions of realism (anthropomorphism) and affinity? The formulation of the hypothesis implies that the phenomenon exists within the stimulus space. However, the axis definitions entail a number of underlying problems. The continuous spectrum suggests that the characteristics of each axis can be quantitatively measured and assessed. But these are essentially qualitative and subjective evaluations, they are far from continuous, and there may be a number of singularities across the valence range.

Ramey goes into some detail on the legitimacy of any scale uniting robots and humans. His main argument is "that the quantitative nature of the spectrum violates the qualitative characteristics of the anchors" (Ramey 2005, p. 8). A scale such as "humanness" or "robotness", he argues, will inevitably dichotomize humans and robots. The measure is really qualitative and its conversion into a quantitative metric is purely artificial. As a robot is a category (qualitative variable), Ramey explains that making a robot more human-like is different from making it less robot-like. Of the two actions, the first unites two categorically different qualities, treating them as if they were quantitative variables on a continuous scale. In this view, therefore, the idealized valley graph is a function of the underlying illogicality of the metric.

Even with proper categorization of the metrics of the Uncanny Valley, it would be necessary to have a good "measurement" of anthropomorphism in terms of the stimuli presented (morphology, action, behaviour). Anthropomorphism refers to the attribution of a human form, human characteristics, or human behaviour to non-human entities such as robots, computers and animals. The bulk of the literature on the Uncanny Valley cites anthropometric (human reference) or iconic (e.g. cartoon-based, non-physical) qualities, but the spectrum from the inert to the human replica is manifestly more complex and includes many other variables.

For instance, the anthropomorphic spectrum cannot be solely based on both form and function. DiSalvo adduces four categories of anthropomorphism (DiSalvo, Gemperle et al. 2005), depending on what aspect of the human form is being imitated: structural (shape), gestural (movement), character-based (predisposition) and awareness-based. Furthermore, anthropomorphism can depart from the form/function paradigm: Epley defines it, for instance, as a process of inference about unobservable characteristics of a nonhuman agent, rather than as a descriptive report of a nonhuman agent's observable or imagined behaviour (Epley, Waytz et al. 2007).

For example, if I consider the five levels of embodiment cited by Johnson (see section 3.2), I will already start with five anthropomorphic scales that are not necessarily aligned in the spectrum. A machine can appear very anthropomorphic at the physiological level but express very little at the social level. Conversely, as an embodied machine, the character HAL from Stanley Kubrick's *2001 Space Odyssey* appears almost abstract (like a camera lens), but its verbal capabilities and communication skills are identical to those of a human. We may conclude that anthropomorphism needs to be better formulated to truly test Mori's hypothesis.

Clearly, a single axis cannot capture all the variations and subtleties of the perception of anthropomorphism. Since the anthropomorphism spectrum has multiple readings, it can generate many niches and many singularities on the horizontal axis (Pollick 2010). For instance, Dautenhahn points out that preconceptions, expectations or anthropomorphic projections can bias the user's attitude even before interaction has occurred (Dautenhahn 2002).

The lack of proper formulation of the axis also leads to a potential bias in the testing of the hypothesis. Since the anthropomorphic axis is bipolar, most of the surveys used to gather information about the Uncanny Valley are also bipolar, forcing respondents to take a stance in a binary divide. For this reason standard surveys like the Godspeed[17] index (Bartneck, Kulić et al. 2009) oppose the use of disjunctions such as fake/natural, machinelike/humanlike, unconscious/conscious, artificial/lifelike, and rigid/elegant (referring to movement) to qualify anthropomorphism.

According to Ramey, the uncanny is more than a vague feeling; it is a cognitive and affective phenomenon:

[17] "Godspeed" because it is intended to help creators of robots on their developmental journey.

> One interprets humans or robots cognitively and affectively as meaningful [*sic*] different kinds, or qualities. An Uncanny Valley arises as a general phenomenon when linking these different categories by certain quantitative metrics that call into question the original qualities, [*sic*] most obviously affecting us when one of those categories is ourselves and our humanity. (p. 13)

What, then, are the fundamental behavioural mechanisms that determine the confrontation of morphology and perceived human affinity? It might be asked if the uncanny can appear for any given form found on the anthropomorphic scale. Equally, movements could be modulated for a given morphology to test the conditions where the uncanny manifests itself. Chapter 4 will investigate the mechanisms and repercussions of anthropomorphism in the perception and reception of *machine performers* by audiences.

3) The divide

The Uncanny Valley has generated extensive discussion within the field of humanoid research. As human-like robots become more technically possible, roboticists argue that Mori had no basis for the right-hand (post-valley) section of the graph. In fact, by challenging the capability of technology to achieve the perfect carbon copy, the Uncanny Valley undermines their entire thesis about the significance of the carbon copy of the human as social agent. As already indicated, the following points have been raised: the lack of formal evidence to derive the affinity curve, the lack of cultural studies within the derivation of the problem, the lack of formal understanding of the spectrum of each axis, and finally the lack of biological/psychological evidence to support the sense of the uncanny. Since most of the experiments about the Uncanny Valley have been designed around the graph, their results will inevitably either demonstrate "escape by design", or supply measurements that fall into the valley, or show that some instances of humanoids elicit a positive affinity response in humans.

Many of these problems may well remain unsolved, but a revealing pattern emerges from the review of literature on the topic, namely that the discussion about the Uncanny Valley polarizes two major groups, which I would call the pro-humanoid and the niche-oriented factions. This polarization is not strictly about confirming or refuting the Uncanny Valley, but more about how researchers utilize the hypothesis to justify their procedures. For instance some pro-humanoids claim that the Uncanny Valley is non-existent, that it merely represents an ill-formulated problem. Despite this widespread questioning of the scientific foundations of the Uncanny Valley, most pro-humanoids have at least surfed Mori's thesis, and look on bridging the gap – or climbing out of the valley – as their ultimate goal. Their quest would then achieve a double goal: they would justify their humanoids as the ultimate human-machine agent, and at the same time accumulate unprecedented evidence to refute or confirm Mori's thesis. The niche-oriented follow Mori's statements more closely; preferring to stay on the left side of the hill and travelling the graph by investigating specific niches for man-machine interactions.

This development has rather left Mori out in the cold. In his thesis he calls for nuance and exploration in the design of robots, but the now omnipresent graph and icon of the valley have been re-appropriated by the creators of humanoids to fuel their research. As morphology and movement are intimately linked to perceived anthropomorphism (see cumulative curves), the graph does not convey all of Mori's writing on the thesis but only one of his conclusions. Issues such as "escape by design", or the impact of movement and knowledge about the essence of the agent (mechanical vs. human) are no longer at the forefront of the main Uncanny Valley discussion.

David Hanson, who developed a realistic robotic copy of his girlfriend's head, has said that the idea of the Uncanny Valley is "really pseudoscientific, but people treat it like it is science" (Ferber 2003), arguing that robot designers should not be conceptually limited by a theory without scientific proof. Sara Kiesler, a human-robot interaction researcher at Carnegie Mellon University, has questioned Uncanny Valley's scientific status, stating, "We have evidence that it's true, and evidence that it's not." (Ferber, 2003) Christoph Bartneck has pointed out that the cultural background of the users might have a considerable influence on how androids are perceived, including their perception of the Uncanny Valley (Bartneck 2008).

The niche-oriented claim that there are sufficient similarities in human-robot interaction to investigate the plausibility of using the Uncanny Valley as a main focus for all aspects of current research, whilst gaining another perspective on how to maximize the success of robot design (Dautenhahn 2002). Dautenhahn himself has warned about the quest for realism:

> Life-like agents that closely mimic human appearance or behaviour can unnecessarily restrict and narrow the apparent and actual functionality of an agent by evoking expectations that the agent cannot fulfil. (Dautenhahn 2002)

Cynthia Breazael has argued that realistic animatronics technology is not quite human enough to be convincing and just human enough to push people's expectations of the intelligence of the machine beyond what can be met by today's technology. This hesitation is a point of some debate in the AI community, with most roboticists believing cartoon identities are OK, but humanlike ones are not. The iconic *Kismet* (Breazeal, Brooks et al. 2003) certainly adopted this path to implement pleasing head features.

Another pertinent observation of the niche-oriented faction is that when the agent is clearly non-human, especially in science-fiction,

> We are happy to fill in the gaps and project features and qualities into these abstract humanoid representations, however, when those gaps are filled in for us by simulations that try to be more realistically humanoid but don't quite get it right, our responses are far less positive. (Cleland 2011)

In her analysis, Cleland joins the "escape by design" of Mori when she cites examples of accepted behaviours in clearly non-human agents in movies and fiction.

Some pro-humanoids base their arguments on cultural acceptance, arguing that prolonged exposure to robot agents generates greater affinity. Their thesis derives from observations of cultures where there is a vast acceptance of robots. For instance, MacDorman and Sone argue that Japanese culture provides the proper environment for the acceptance of the humanoid without much impact of the Uncanny Valley (Sone 2008; MacDorman, Vasudevan et al. 2009). However, despite media hype about Japan's robot craze, response similarities in surveys suggest factors other than attitude better explain robot adoption. These include differences in history and religion, personal and human identity, economic structure, professional specialization, and government policy.

Bartneck (Bartneck 2007) introduced a framing theory to further analyse the Uncanny Valley, but its results seem to point in a different direction. The framing theory calls upon a set of a priori knowledge aspects conditioning the observation of an agent as either robotic or human. But empirical research indicates that framing has no significant impact on the measurements and that the plotted measurements do not produce a significant valley but rather point to a cliff immediately before the valley. Bartneck's conclusion is that it is unwise to build highly human-like androids, since positive reactions are more frequently observed with machine-like robots.

As a lone voice within the scientific community, Hanson claims that acceptance is based on aesthetics, regardless of the level of realism:

> Although the uncanny exists, the inherent, unavoidable dip (or valley) may be an illusion. Extremely abstract robots can be uncanny if the aesthetic is off, as can cosmetically atypical humans. Thus, the uncanny occupies a continuum ranging from the abstract to the real, although norms of acceptability may narrow as one approaches human likeness. However, if the aesthetic is right, any level of realism or abstraction can be appealing. If so, then avoiding or creating an uncanny effect just depends on the quality of the aesthetic design, regardless of the level of realism. (Hanson 2006)

Looking more specifically at the Uncanny Valley and at some experiments from the robotics field, Liu criticizes the modality of the interaction: "…we are told that human participants prefer to interact with 'positive' robots and avoid negative-looking robots or negatively behaving robots, whatever their negativity is supposed to mean at social and psychic levels". Liu returns to Freud and states that the uncanny in AI engineering has still not been adequately investigated:

> Whereas Freud would have been intrigued by their experiments, the design of such experiments seems to reveal more about how the scientists themselves view the functions of the human brain with respect to intentions, goals or desires of others – human or robot – in an already socialized game setting than how they can enlighten us about the uncanny in human-robots interactions. (Liu 2011, p. 228)

Actually, since the emergence of geminoids and actroids, humanoids such as Asimo are now considered too mechanical and set on the left side of the hill, whereas more fleshily realistic silicon humanoids are headed more to the right side of the graph. I see these humanoids as the contemporary version of the Jacquet-Droz automatons, where the creators demonstrated their know-how (Wood 2002). Neither the virtuosity of the machine nor the quality of replication is central to the uncanniness of these modern stunts. The unfamiliar actually depends more on the obscure quests of their makers and their voluntary staging of machines as unusual occurrences such as a girlfriend's head, a twin, or a copy of a popular star (see Figure 21). About the Chess Player, Reichardt wrote in her seminal book *Robots: Fact, Fiction and Prediction*:

> In robot lore, truth as a concept may not seem the most relevant or vital criterion, but fraud in automatons is worse than human deception because its association with science makes it impervious to corruption. (Reichardt 1978, p. 25)

Figure 21. Uncanny occurrences: a decapitated head, geminoid and actroid
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2.3.2. Artistic and Cultural Stances

Shifting the approach of the Uncanny Valley from a technological to a social and aesthetic perspective can shed new light on the issues involved. As Ramey asserts, “the uncanny is not unavoidable and can in principle be appraised quite differently and flexibly given a different knowledge ground on which to build meaning” (p. 12). Art and aesthetics provide this ground, for, rather than considering ambivalence and ambiguity as negative characteristics, art values multiple and unstable meanings. Art also re-formulates, re-appropriates and challenges assumptions and preconceptions. Hence de-familiarization is one of its many processes and the uncanny is an integral part of a modern aesthetic sensibility. Scientific and technological AI discourse tends to view the uncanny as the product of pseudo-natural perception without reference to its cultural codification. Art sets different accents. Without covering all aspects of the uncanny in this vast field, I will in the following pages point to some representative issues in art and aesthetics that might well broaden the scientific approach to the Uncanny Valley. Among these are the cultural backgrounds of robot perception.

1) Suspension of disbelief

When roboticist Brian Duffy analyses the suspension of disbelief in social robotics, he admits that “Scientists and engineers to date have tended to imitate or fake the real rather than create fiction. To date this has generally led to more technological feats rather than socially capable robots.” (Duffy and Zawieska 2012, p. 484)

Furthermore, side-tracked by the quest for “hard” models of an Uncanny Valley theory, scientists have not fully explored perceptual areas that are topical in the arts such as alienation vs. identification, de-familiarization vs. familiarization, and ostranenie vs. repetition (in the sense of reproducibility).

This act of suspension of disbelief will be analysed in more detail in Chapter 4, but meanwhile I will briefly introduce how strategies of fiction can alter the dip of the Uncanny Valley. The willing act of poetic faith as described by Samuel Taylor Coleridge[18] allows non-realistic elements to be enjoyed in literary works. Ramey refers to Freud when he writes that one does not feel a sense of the uncanny in fiction and art (relative to the same experience in reality) because “we adapt our judgment to the conditions of the writer’s fictional reality and treat souls, spirits and ghosts as if they were fully entitled to exist, just as we are in our material reality” (Ramey 2005, p. 8). Going beyond fiction itself, Jentsch (according to Liu) had already suggested that literary strategies such as leaving the reader in a state of uncertainty were reliable ways to evoke the uncanny (Liu 2011, p. 212).

2) Credibility of the facsimile.

When Gaby Woods analyses *The Piano Player*, she describes an exposure to automata that contains several levels of cultural codification: “Their creators wanted them to look young so that the mistakes resulting from their early efforts would be forgiven […]”; and “[a] vestal virgin with a heart of steel […] [she] is apparently agitated with an anxiety and diffidence not always felt in real life” (Wood 2002). And when Mitchell argues that images come alive in two basic forms that vacillate between figurative and literal senses of vitality or animation, he also refers to culturally codified bodies:

> They come alive because the viewers believe they are alive (weeping madonnas) or because a clever artist has engineered them to appear alive (puppeteer or ventriloquist). The notions of images as life-forms always equivocates between questions of belief and knowledge, fantasy and technology, the golem and the clone. The middle space, which Freud called the Uncanny, is perhaps the best name for the location of images as media in their own right. (Mitchell 2010), p. 295; Liu 2011, p. 218)

[18] Coleridge coined the expression “suspension of disbelief” in *Biographia Literaria* (1817).

Even given a perfect replica of a human in some distant future, the rejection of these robots might not be based on the Uncanny Valley but on the cultural background of the audience. Plotting the Uncanny Valley in the future to the gap that divides simile from metaphor will become the gap between like and is. The replicant in Philip K Dick's novel *Do Electric Sheep Dream* – as transported to the film *Blade Runner* (1982) – depicts this situation. The Uncanny Valley idea resembles Freud's writing about the narcissism of minor differences, where feuds between communities of adjoining territories ridicule each other. This territory is also depicted by Steve Dixon's notion of "metallic camp" (Dixon 2004, p. 273) when he discusses performance examples in the creative arts. Dixon argues that "robotic movement mimics and exaggerates but never achieves the human, just as camp movement mimics and exaggerates, but never achieves womanhood" (p. 274), and that camp is an essential factor in anthropomorphic and zoomorphic robot performance. The place where the credibility gap or the Uncanny Valley occurs is not, for him, the point furthest from the truth, but the point closest to it. As observed by kinetic artist Kirbey, when a kinetic artwork is almost credible, it lacks credibility (Rickey 1963). Following Derrida's strategic valorisation of the suppressed supplementary term of any binary, my own works investigate the dichotomy of human/non-human in the grey area that lies between the two dimensions.

3) The uncanny as an aesthetic experience

Fischer-Lichte describes the state of destabilization in performance audiences and the in-between space it creates – where the valley should shy away – as a stimulating situation to develop an aesthetic of this unstable conjuncture:

> So, by blending the real and the fictional and thereby transferring the spectator into a state of liminality, these performances allowed for a particular aesthetic experience which ran counter to our traditional understanding of what aesthetic experience is about, and in this way stimulated a new discussion of its very concept, so central for all forms of art in the Western world since 1800. (Fischer-Lichte 2008), p. 95)

The term "uncanny" functions both scientifically and aesthetically. Pollick suggests, from his psychological standpoint, that "we can look at falling into the Uncanny Valley not from the usual perspective of ever more realistic artefacts, but instead from the viewpoint of how normal human activity might be modulated to fall into the same Uncanny Valley" (Pollick 2007). For instance, the artist Kozin describes his uncanny encounters with deformed bodies as breaking pre-formed conceptions:

> These other experiences prevented me from both simply stating the fact of abnormality but also connecting the abnormal body to the lived body of mine in an act of empathetic congruence. It did manage, however, to awaken the sense of wonder, the very awe that arises from encountering something, someone so odd that no available pre-formed measure is capable of giving the encounter any sensible explanation. (Kozin 2006)

Mori's publication calls for more metaphorical design for humanoid artefacts, but most writing and research about the Uncanny Valley does not seek for alternative modes of representation across the spectrum of either anthropomorphism or movement.

4) Staging the Uncanny

As Fischer-Lichte observes, performance happens when reality and fiction collide (Fischer-Lichte 2008), a similar contention to the one raised by the Uncanny Valley. The staging of the robot in science can be seen as a very specific theatrical genre with its own cultural rules. The Uncanny Valley is not, therefore, just a tool to judge the appearance of the robot: it can also generate a staging of the uncanny itself.

The context in which one experiences uncanny objects also frames one's perceptions. What happens when the ontological questioning is reinforced by the space where the bodily encounter with the work of art occurs? Performing spaces can be considered both as a dynamic constituent – in the sense of a cultural extension – of the experiential body (Öztürk 2010) and also, broadly speaking, as zones of cultural interaction (public squares, theatres, card-tables, stadiums) where reality is in some way suspended (Cleland 2011). Öztürk analyses the functions of space and how it infuses feelings bearing on the ontological questioning of reality. She considers the corporeality (akin to the *spatiality* of the situated body) of a body hesitant over ambiguous impulses borne and/or magnified by space. Cleland uses the analogy of the magic circle[19] when she looks at performances and cultural spaces (galleries, museums). She points out many zones of fantasy where the suspension of disbelief, and temporary worlds within the ordinary world, create environments akin to the uncanny. In such zones, the eerie could happen without triggering feelings of the uncanny. Equally, the zones provide safe environments to explore the uncanny without real threat.

[19] Used in game and play analysis

Anthony Vilder coined the phrase “the architectural uncanny” with respect to the interaction of mind and space: in other words the aesthetic dimension of mental projection impacting a spatial configuration. Vilder argued that neither a building nor special effects can be guaranteed to provoke an uncanny feeling:

> […] the uncanny is not a property of the space itself nor can it be provoked by any particular spatial conformation; it is, in its aesthetic dimension, a representation of a mental state of projection that precisely elides the boundaries of the real and the unreal in order to provoke a disturbing ambiguity, a slippage between waking and dreaming. (Vidler 1994, p. 11)

5) Social concerns

Trends in human-robot interaction, further intensified under the microscope of the Uncanny Valley, raise many concerns seen from the perspective of the humanities and cultural studies (Weber 2005; Suchman 2007; Weber 2007). The strongly gender-stereotyped design of social robots as women, infants or pets calls for a critique of patterns, norms and roles. It encodes the theoretical concepts that shape technological construction, and it also supports naïve and non-demanding attitudes towards machines (e.g. mother and child, owner and pet, client and receptionist or waiter). These stereotypical patterns of social interaction lead to a standardisation of the relationship between social machines and people. Standardisation also exists in the emotions implicit in robot behaviour. These are usually limited in number to six.

2.3.3. Case study: Geminoid H1-1 and HUBO’s legs

I would like to compare two of my personal encounters with the creatures of android makers. Both robots have a latent potential to fall into the Uncanny Valley. The first is the geminoid of Prof. Ishiguro (Ishiguro 2006; Nishio, Ishiguro et al. 2007) and the ATR laboratory in Osaka, the result of an ongoing effort to make verisimilar machines that culminated in visual carbon copies of people. *Geminoid H1-1* has become the icon of recent androids and also of the Uncanny Valley. The doppelganger of its maker, it has attracted worldwide media attention and penetrated the collective imagination. The second robot is HUBO by Prof. Oh (Oh, Hanson et al. 2006) from the KAIST robotic laboratory in Korea. HUBO is anatomically similar to a human, while keeping a certain mechanical flair; it has a plastic shell as opposed to a silicon skin, and the educated eye can imagine all the mechatronics involved in its bipedal locomotion. HUBO has had many variants and Hanson, for instance, made a copy of Albert Einstein's head to complete its body. HUBO is more a descendant of the equally iconic Asimo by Honda, while Ishiguro's geminoid attempts to recreate fleshily human features (hair, eyes and skin). HUBO is an autonomous bipedal machine, whereas the geminoid is teleoperated and incapable of locomotion – Ishiguro's doppelganger always sits on a chair.

When I first experienced Ishiguro's geminoid at Ars Electronica 2009, my uncanny sensation had nothing to do with the robot in action. What I found striking was the freak-show it created: the excitement of the crowd trying to find out differences between the original and the copy and the ongoing pokes to the android's skin to complement the visual perception with a tactile one. My own curiosity was targeted at another level; it was concentrated on the bodily expression of the geminoid when it was simply turned off (see Figure 22). The body appeared to be in rigor mortis, while the living version was busy working on cables and preparing the demonstration. This uncanny sensation was much closer to the feeling experienced in a wax museum than that described by Mori. I never felt any agency in this amalgam of silicon and motors, as I never considered the geminoid to have convincing human movements or behaviour. Actually, the movements feel more like a twitch than anything else (Paré and Grimaud 2011) and the geminoid cannot engage in any complex bodily action. Finally, Ars Electronica has brought the laboratory set-up into the art museum, endowing this demonstration with performative attributes. Audiences read this action as an artwork, the staging of the confrontation of a man with his double. In the actual situation of the exhibition, Ishiguro was lecturing us, as in any scientific presentation or demonstration, about the geminoid, and complementing his thesis with a typical question and answer session.

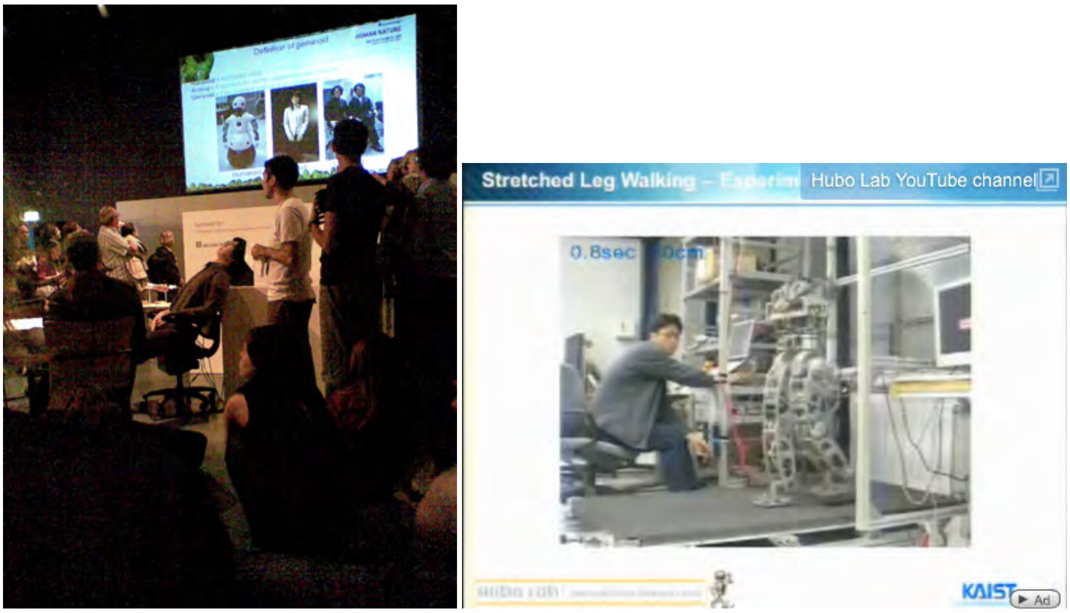


Figure 22. *Geminoid H1-1* (Ars 99) and *KAIST* biped tests
Permission to reproduce the right image has been granted by IEEE.

I had a more viscerally uncanny sensation when I visited the laboratory of Prof. Oh and his progeny. Like many other robotics labs, it concentrates on developing bipedal humanoids, often relying heavily on (rigid) mechatronics. In the corner of the lab there was a long catwalk and at the end of it, half of an android body (only the legs). The professor started this machine and it ran towards me. The image of out-of-control decapitated animals (or even humans) overwhelmed me. Between this image of horror and my perception that this robot had no head, I was unsure if it would stop in time. This massive piece of metal suddenly came to a halt right in the front of me, as if to provoke me. My body reacted by quickly jumping backwards, which was acclaimed by a huge grin from the professor: I imagine his test was (for him) conclusive.

In both cases (*Geminoid* and *HUBO*), my uncanny experience is not rooted in the intrinsic affinity I have towards the agent but in the affinity towards the agent within its context, staging and environment. These factors, which are known before I enter the situation, taint any original and neutral scenario such as walking unprepared into a situation that is perceived as uncanny only when it arises. In both cases, audiences (including myself) are fully aware that these androids are mechanical and not human. Therefore this diminishes any categorical man-machine uncertainty associated with the Uncanny Valley. The most mechanical object, not the most human-like, triggered my own uncanny experience. At this stage, Ishiguro's geminoid can barely perform any movement, and to evaluate its anthropomorphism inevitably brings up the arguments of Ramey about the ill-formed scale of measurement. The form is human, some visual features are strikingly verisimilar, but the body in action is far removed from approaching human capacities. Actually, the geminoid is remote controlled, with the voice and facial movements manipulated from a control booth at a separate location. What makes it uncannily human is its improbable duo act with Ishiguro as a ventriloquist[20].

In “Human+” at the Science Gallery Dublin, there was a series of large print pictures of androids (Armstrong Rachel , Spillane Charles et al. 2011). The series depicted either situations where the machines were performing human activities (e.g. cooking) or situations where the original human and the robotic copy were staged next to each other. I observed that the audience turned this uncanny vision into a play of finding the “errors”, looking at both static images for visual cues to distinguish the mechanical from the human. Even the scientific publication, IEEE Spectrum, directly invited the reader to play this game by glancing from left to right (Guizzo 2010).

Figure 23. Ishiguro's *Geminoid H1-1* printed fold
Permission to reproduce this image has been granted by IEEE.

[20] Popular culture has transformed the old forms of entertainment such as clowning and ventriloquism into eerie and creepy experiences.

When we look at how Ishiguro stages his appearance(s), it always follows the same mise-en-scene: the Ishiguros are set side-by-side to evoke a comparison between the flesh and the nuts and bolts versions. This staging exacerbates our reflex to categorize the human and the machine, just as the graph of the Uncanny Valley implicitly forces us to position an object on the right or left of the divide. Once again, science drives the audience into a quest for realism in a situation that should call for broader behaviour: there is more at stake here than merely distinguishing the animate from the animated.

Ishiguro is currently staging an android in a theatre play (Ogawa, Taura et al. 2012), to which I will return in Chapter 4. When an audience is presented with an android actor, it has to overcome the reflex of constantly looking for visual and expressive cues that distinguish the machine from a hypothetical human performer. The following section brings different models of this unstable scenario, along with observations about the saturation potential arising from the reflex described above, and how theatre empowers a multi-stable environment.

2.4. Shifting the thesis for machine performers

The current formulation of the Uncanny Valley has two underlying motifs: its negative connotations (fear, death, horror) and its concern with human-looking objects. The transference of the valley to machine performers does not, as Jentsch proposes, derive from the obscurity of animated objects: “as long as the doubt as to the nature of the perceived movement lasts, and with it the obscurity of its cause, a feeling of terror persists in the person concerned” (Jentsch 1997). Under an embodiment perspective, the nature of these movements should look as far as possible integral to and initiated from the body, rather than obscure. Nevertheless, if the attention of the audience is focused on the otherness of the machine performer’s animation, it is bound to consider the performance inadequate. This does not necessarily mean, however, that it will fall into the Uncanny Valley. In a manner analogous to Brecht’s “alienation”, it may perceive that very inadequacy as a source of enjoyment. In other words, I need to reformulate the Uncanny Valley not as a problem but as an aesthetic experience in its own right, and the affinity scale as a qualitative description of the acceptance of a machine performer on its own terms as a true performer, i.e. a credible agent in its *present* embodiment on stage.

Many aspects of the rejection or acceptance of robots are hardly covered by research on the Uncanny Valley. For instance, the length of exposure to the machines could play an important role, whereas most lab experiments last only a few minutes. Practically, the experiments (unlike many of our social interactions) can hardly span more than an hour. In a performance context, the length of exposure would be typically longer than in a lab experiment. Here, I am not looking to scale or compare durations, but to consider the time factor in the formulation of affinity. It is more than probable that audience reactions change throughout the exposure to machine performers during a stage enactment.

As my own work is either mechanomorphic or zoomorphic (rarely strongly anthropomorphic), I would seek for a definition that does not include anthropomorphism as a correlate of the agent's affinity. Actually, if I am looking at using the body as an experimental variable (Chapter 1 on Kaplan), anthropomorphism has to be fully revaluated in its contribution to the thesis to enable the inclusion of arbitrary shapes. After all, anthropomorphism is a shifting qualitative attribute dependent on exposure, cultural codes and context, to name only a few variables.

What is lacking is a deeper study of the phenomenon of perceptual dissonance. For instance, how can perceptual dissonance lead to an unbearable position in science and at the same time be such a source of inspiration in the arts? The scientific world wants to be on one side or the other of the valley, feeling this state of limbo too unstable for its belief system. Perhaps they find there is not enough "truth" at the bottom of the valley. In opposition to the concern with the Uncanny Valley, my own works posit the essence of the machine performer in its double vision, the core of its identity being neither just a mechanical self-moving artefact nor a facsimile of the human.

In this section, I will present four models that focus on the Uncanny Valley in robotic terms and a fifth that involves theatre performance. I will demonstrate that the undecidability in the classification of robots is exacerbated by perceptual and/or conceptual loops. I will point out how various analyses from different perspectives lead to very similar conclusions. Finally, I will look into an adaptation of these models to address an alternative to the Uncanny Valley thesis targeted on machine performers.

2.4.1. Paré's confusion cycles

Robotic Artist Zaven Paré recently published a book about his experience at Ishiguro's laboratory (Paré and Grimaud 2011). Written more as a journal than an academic essay, Paré's book becomes an ethnographic study on how these scientific experiments are conducted. His personal experience reveals the undocumented side of Ishiguro's methodology in investigating his creatures. In a similar way some years earlier Suchman and Weber reported on their own experiences with social robots (Suchman 2003; Weber 2007).

Paré observes that the surreal interaction with Ishiguro's geminoid is cyclic. Sometimes the engagement starts and then quickly falls off, sometimes it entails a cumulative process, and sometimes it becomes a saturating experience that has to stop if it is not to end in delirium. Paré speculates that the engagement operates on a typical loop scheme (see Figure 24): when a state of "ontological" confusion arises, it leads to a cycle with the following steps: dissociation, multiplication of presence (representation of the geminoid), and saturation. This saturation then leads back to the starting point, the unsolvable question of ontological status (p. 98). Paré further points out that the key element of the geminoid's experimental set-up is that each of its components has the propensity to generate signs, mise-en-scene variations and interpreted behaviours (p. 102).

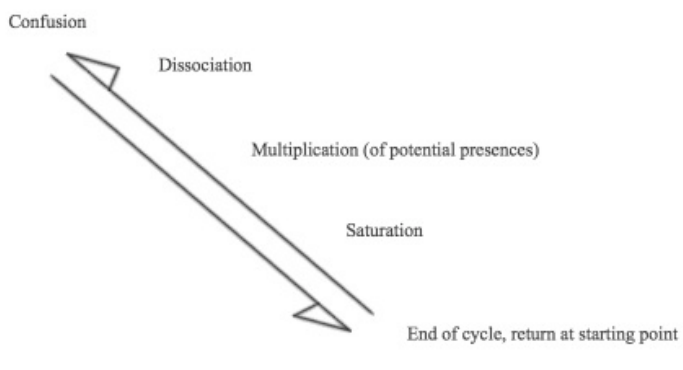


Figure 24. Paré's confusion cycle
Permission to reproduce this image has been granted by the artist.

Paré wonders if audiences can sustain a lengthy surreal dialogue and how long one can live in a scenario with a robot. He observes that all these robotic experiments fall into the dilemma of a relationship that is either constructed (artificial) or imposed (levelled down by the less powerful agent). These are questions raised by Paré when he coins the description of the engagement with the geminoid as the problem of extending the “2 to 10 seconds of confusion”[21], the initial spark of confusion or enchantment. Once the surprise effect has vanished, even if emotional and physical restraints are installed, the confusion comes back, untamed, incoherent and uninvited, unwillingly imposed upon the experimenters themselves (p. 161-162).

2.4.2. Kang’s controlled parameters

Historian Misoon Kang’s essay questions our emotional, imaginative, and intellectual reactions to the illusion that robots are alive or lifelike. Kang’s essay develops around an anecdotal encounter with a street performer, combined with the ritualistic complicity of the audience, featuring a man pretending to be a machine that pretends to be a man. Kang builds around the two faces of this encounter, the stillness and the sudden movements of the figure, shifting the viewer from a contemplative to an eerie state. He explores the lack of explanation as to “how the automaton can switch from being a frightening, uncanny thing in one context, to an amusing and captivating object in another” (Kang 2009).

There is no doubt for Kang that the uncanny is a major component of our reaction to the robot, but he questions what makes it an interesting subject and how it can arouse such a wide range of emotions. He builds his model of analysis on a consideration of the immediate, almost visceral impact of the automaton. For Kang, the explanation of the automaton’s power must start at the level of perception, cognition and emotional reaction. What begins as fascination or amusement has the potentiality to turn into the sublime, and from there into terror or horror. Kang establishes the following corollaries, subsumed in tabular form in Table 7:

[21] This expression was also used by Ishiguro in his presentation at ICRA 2012.

I. The less powerful (often but not always because it is small) and more apparently mechanical a robot is, the more amusing it is.

II. The more powerful (often but not always because it is bigger) a machine, the less amusing it is and the more sublime.

III. The technological sublime turns into terror the moment the powerful machine appears to have gone out of human control.

IV. The more lifelike a robot, the greater the sense of the uncanny sublime.

V. The uncanny sublime loses its pleasurable aspect and turns into horror when a human being turns out to be a robot or vice versa in an unexpected way.

	WITHIN CONTROLLED PARAMETER		BEYOND CONTROLLED PARAMETER
PHYSICAL (Controlled parameter defined by the knowledge that a machine can cause no harm because it is under control)	A machine that is inherently harmless and interesting because it is particularly useful or beautiful – FASCINATION→	A powerful machine that is potentially dangerous but it is under control so that it can cause no harm – SUBLIME→	A powerful machine that is dangerous and it can cause harm at any moment because it is no longer under human control – TERROR
CONCEPTUAL (Controlled parameter defined by the knowledge that the robot is not really alive, no matter how good it is at pretending to be)	A robot that imitates life but utterly fails to convince that it is really alive - AMUSEMENT→	A robot that does an excellent job of imitating life though we can tell that it is not really alive – UNCANNY SUBLIME→	A robot that does such a good of imitating life that we cannot tell (even if temporarily) if it is a living being or not – HORROR

Table 7. Emotional responses towards machinery (Kang 2011)
Permission to reproduce this table has been granted by the author.

2.4.3. Misselhorn's imaginative perception

Philosopher Catrin Misselhorn investigates a model of empathy involving a kind of imaginative perception and claims that this perception fails in the case of very humanlike objects (Misselhorn 2009). Misselhorn constructs her arguments on the basis of three questions that the Uncanny Valley has to answer: why do we feel empathy towards non-human entities (with some human characteristics), why do we stop feeling empathy when they become very humanlike, and why does empathy then give way to eeriness. Misselhorn's angle of analysis suggests that it is the perception of an inanimate object that produces empathy in the beholder, not its pretence at being human.

Misselhorn builds her empathy model on Sobel and Wilson's conceptual exclusion of empathy for inanimate objects. She then complements this model of empathy with "*T-ing"* where T stands for some behaviour or expression that is reliably correlated with an emotion E (e.g. crying, laughing). Finally she links the inanimate to the human via the equation that seeing the T-ing of an inanimate object we imagine ourselves to be perceiving a human T-ing. To resume, here are the three incremental formulation of her empathy model:

> (1) S empathizes with O's experience of emotion E if and only if O feels E, S believes that O feels E, and this causes S to feel E for O. (Sober and Wilson 1998, p. 234 f.)
>
> (2) S empathizes with O's experience of emotion E if S perceives O's T-ing and this perception causes S to feel E for O. (Maibom 2007, p. 168) (Maibom 2007)
>
> (3) S empathizes with an inanimate object's imagined experience of emotion E if S imaginatively perceives the inanimate object's T-ing and this imaginative perception causes S to feel E for the inanimate object.

Misselhorn then introduces the imaginative perception paradigm set forth in formulation (3): imagining the perceptual experience of an object F to be the perceptual experience of an object G involves salient similarities between F and G and also triggers the concept of G. Misselhorn speculates that "as a rule of thumb, the more features there are, and the more typical and salient they are, the stronger will the concept of a (or the) G be triggered, and the more vivid will the imagining and phenomenal feel be" (Misselhorn 2009, p. 354). She qualifies the act/process of perception (and the imagined object) as a "blended" phenomenological situation; one sees an F and not a G but this influences its phenomenological 'feel', because perceiving F feels to some extent like perceiving G. To resume, she postulates:

> The human-like features M of an inanimate object trigger the concept of a human N, for that reason, seeing the T-ing of an inanimate object feels (to some extent) like seeing a human T-ing. (Misselhorn 2009, p. 354)

Finally, Misselhorn attacks the problem of the breach of empathy in the Uncanny Valley. While the triggering of the concept of humanness is very strong, applying the concept fails, since the perception of the object is not accepted as an instance of the concept. Due to the similarity in the features, the concept is repeatedly re-triggered and hangs, as it were, on the verge of being elicited. The process of empathy is interrupted, suspended between activation and deactivation of the concept of the human:

> This leads to a kind of very fast oscillation between four situations, which resembles a gestalt switch: the mere triggering of the concept, the reaching of the threshold of concept application, the failure of concept application resulting in a complete turning off of the concept, and the renewed triggering in keeping on to perceive the object. (p. 357)

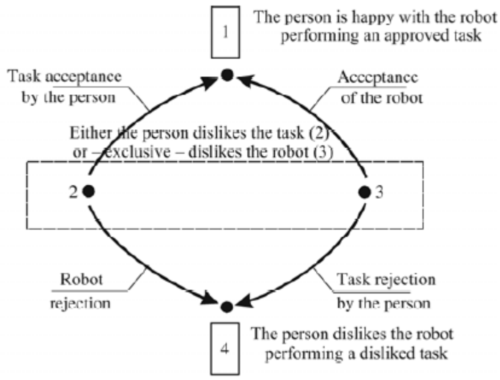
Misselhorn adds that the failure in concept application could amount to a sense of conceptual confusion and that the Uncanny Valley implies other elements emanating from the failure, a specific quality of eeriness born from a particular kind of confusion between the dead and the alive.

2.4.4. Tondu and Bardou's balance theory

Roboticist Bertrand Tondu and psychologist Nicole Bardou revisit Heider's balance theory (Heider 1946; Cartwright and Harary 1956) and Festinger's cognitive dissonance theory (Festinger 1957) to provide a social psychology framework of analysis, and to distance this approach from the recurrent Freudian "innate fear of death" analysis of the Valley.

These authors refer to Leon Festinger, who developed a theory of cognitive dissonance as the feeling of uncomfortable tension that comes from holding two conflicting thoughts at the same time (Festinger 1957). To this the authors add Heider's balance theory, which formalizes social exchanges between people. This theory is based on a tendency to achieve a balanced state deprived of tension in all exchanges. Heider plots relationships between entities as either positive or negative. In the case of a dyad, a balanced state is achieved when relations are either positive or negative in all respects. This dyad situation compares to Festinger's dissonance theory. Triads, for Heider, can create a social structure between all the elements involved, where a state of balance can also be determined. He postulates that balanced states exist if all relations are positive or if two are negative and one positive. Tondu and Bardou then posit such social structure as made of three elements: a human, a robot and the task performed by the robot. They claim that the Uncanny Valley effect is limited in this situation as it generates a "weak" cognitive dissonance demonstrated by the coverage of possibilities of balanced states (Tondu and Bardou 2011, p. 344).

	Person-robot (p, r)	Person-function (p, f)	Robot-function (r, f)	Relation state
1	+	+	+	Balanced
2	+	–	+	Unbalanced
3	–	+	+	Unbalanced
4	–	–	+	Balanced



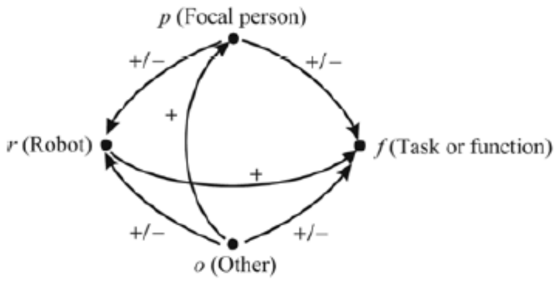


Figure 25. Social interactions in dyadic (up) and triadic (down) configurations (Ibid., p. 344)
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In attempting to broaden the application of balance theory to their Uncanny Valley analysis, they bring the case study of another entity into the relationships: a human bystander. The upshot is an explosion of possible permutations (64) in which a balance degree factor is calculated. It is then noted that not all combinations generate the same level of balance, and they conclude that a lower balance level would generate a deeper valley. They further claim that by modulating the task to be performed by the robot, the depth of the dip can also be modulated. Their contribution to the debate is to show theoretically that in the Uncanny Valley there is a task dependence factor in the affinity generated towards the robot.

2.4.5. Fischer-Lichte multistability

Performance theorist Erika Fischer-Lichte examines aesthetic experiences that arise from transgressions between the dichotomous pair of the fictional and the real (Fischer-Lichte 2008). More specifically, she analyses tensions between the phenomenal body and the semiotic body. These tensions appear when the perception of the actor’s body shifts and oscillates from the phenomenal (or real) to the dramatic (or fictional). Fischer-Lichte introduces perceptual multistability as a constant transition between two orders of perception, the order of presence and the order of representation:

> Perceiving the 'real', phenomenal body of the actor, his bodily being-in-the-world, lays the foundation for a particular order of perception, to perceive the actor's body as sign for a fictional character, for a very different order of perception. Each of the two orders generates meaning according to its own principles, which become dominant the moment one order is stabilized. (Fischer-Lichte 2008, p. 87)

This perceptual multistability is responsible for the fact that neither of the two orders becomes permanently stabilized. There is a dynamic in each shift: it can become goal-oriented or chaotic. Each turn results in the perception of new elements, incorporated in a new order of perception. Fischer-Lichte evaluates this as a device not to eradicate the dramatic figure but to disturb our perception. The frequency of the multistability depends on the situation and performance. If the frequency is too high, the difference between the orders loses its relevance and attention focuses on the rupture itself rather than on the subject. This rate of disruption makes the spectator aware that she cannot control the transition. She might try to adjust her perception anew, but she will soon notice that the shift occurs anyway and is outside her control. She will then experience her perception as emergent but nevertheless consciously performed.

According to Fischer-Lichte, the self is a prominent factor in the way audiences perceive presence. Audiences can create associative chains of meaning that are not necessarily directly related to what is perceived and hardly comprehend associations between presence and theatrical elements:

> Based on self-referentiality, the order of presence allows meanings to emerge over which the perceiving subjects have no control. (Ibid., p. 150)

Being suspended between the two orders, the perceiver finds himself in a condition of liminality. Destabilization lies here not only in the orders of representation and presence but also more importantly in the self:

> Aesthetic experience, in all these cases, is to be regarded as a liminal experience, as an experience of being 'betwixt and between', as Victor Turner put it, an experience of crisis. It is, above all, the collapse of the 'real' versus 'fictional' opposition which induces the crisis (Ibid., p. 95)

2.4.6. Hybrid reformulation

Scholars and practitioners from various backgrounds have issued the five models set forth in this discussion: an artist robot-maker, an art historian, a philosopher, a psychologist teamed with a roboticist and a performance theorist. Their analyses share the observation of an unstable oscillation of perception and of a liminal space engendered by this instability. Their findings correlate in part or in whole on a phenomenological scale.

Paré cites detailed observations about a communicative experience with Ishiguro's geminoid. He reveals that the device becomes credible only peripherally, by accidentally triggering details of its embodiment in minute movements. The human comes back into the communication loop with playful dissonances between the voice (operator), the context (topic) and body (a twitch). Paré then witnesses the collision of the orders of presence and representation expounded by Fischer-Lichte. Likewise his saturation point resembles the moment when the frequency of multistability becomes too high and makes it the point of focus for the participant.

Kang is intrigued by the way the robot can be playful then become frightening. He bases his analysis of the Uncanny Valley on the rupture point between the sublime and the terror/horror emanating from the robots. I think most robots – at least real if not necessarily fictional ones – remain in the controlled parameter section. When I experienced the humanoids of the previous section, I knew these robots were well within controlled parameters. If I extrapolate from Kang and analyse my encounters, I would not stay in (or come close to) the area of horror or terror, I would come back to lower levels in Kang's order, where the robot and the situation are more playful (aka Paré). Or worse, I would simply become bored and the robots would not sustain my attention anymore.

While Paré looks at this perceptual loop as an experimental bug, trying to locate its origin, Kang looks into the final (gestalt switch) reaction to this incongruence and Misselhorn elicits the triggering of the gestalt switch, Fischer-Lichte reads this unstable and multistable situation in the light of the aesthetics it brings to the audience. Nonetheless, Paré's analysis about a scheme of interaction emerging with the doppelganger chimes in with Fischer-Lichte's multistability.

In this discussion, the body is an instance of an anthropomorphic object: T-ing the human by some means, a human lookalike, etc. What happens when the body becomes too remote from any definition of the human, and empathy requires considerable imagination? What would the phenomenological mechanisms of perception be between this object and the human? To develop a thesis about stage acceptance of machine performers, I need to encompass anthropocentric morphologies and behaviours. At the same time, the human audience is the preceptor and the receptor of the machine performers. Hence I need to find some common ground between performers and audience.

If I consider audience perception of a machine performer on a scale of feeling that runs from qualifying it as animate to qualifying it as animated, I could utilize this bipolar scale to gauge a successful machine performer. Moreover, such a scale does not infringe the categorical boundaries of its anchors (see Ramey section 2.3). If the machine performer is considered animate, this must mean more than that its movements are simply congruent with the morphology of a machine. It implies that other layers of embodiment, with their specific readings of this mechanical body, are congruent with its perceived behaviour. In social robotics the machine is seen as ubiquitous, but it does not guarantee this congruence. So far as the credibility of puppets is concerned, Duffy observes:

> Artists can create puppets that resemble human beings as closely as possible (an imitative approach) or they can schematically or more abstractly represent animate beings (a conceptual approach) [31]. The choice of which is taken often depends on the themes and stories being told – a concept often ignored in social robotics. (Duffy and Zawieska 2012, p. 485)

When the nominal functions of a machine are shifted and adapted to meet a narrative role, its apparent intentionality becomes grounded in its behaviours and the machine shifts from the animated to the animate. The animate object facilitates empathy and identification from the audience, while the animated one reminds a viewer of the object's mechanical essence. It is not an embodiment but a strict simulation. An animate machine performer would then have a strong sense of presence while an animated machine performer would possess a weak presence, close to that of a casual object. An animate machine should also embody flaws and limitations to alleviate the resurgence of conceptual uncertainty without considering them as a malfunction:

> There is no explanation, however, of why at a certain level of resemblance to life, flaws should suddenly become sources of discomfort, when they were unproblematic in less lifelike machines. Perhaps the cause of the uncanny is not in the flaws, but the conceptual uncertainty that they cause in the perceiving mind. (Kang 2009)

Multiple oscillations between human and machine, animate and animated, subject and object in the performer are fundamental elements of the multiple ontological (or semiotic) states found in the machine performer. If I try to remain faithful to Fischer-Lichte, I need to revisit her perceptual multistability theory, as she states that objects cannot enjoy or evoke presence:

> Objects are frequently perceived as present, especially in theatre performances and performance events. The radical concept of presence requires the idea of an embodied mind at its centre and therefore has to be limited to human beings. (Fischer-Lichte 2008, p. 100)

The reformulation of the Uncanny Valley into a qualitative assertion of the sensed affinity (credibility) of the machine performer will continue in the next two chapters, where I will look at why and how this object can be considered as equal in rank to human performers.

2.5. Contributing work: *Area V5*

The project *Area V5* was initiated within the context of a large museum exhibit about the human mind. The Museum of Civilization of Quebec City commissioned me to create an artwork related to current trends in artificial intelligence and the future of "thinking".

In this context, I aimed at establishing reflection in the audience about social robots and their still very limited interactions with humans, and at exploring the potential of the uncanny in its embodiment in the mechanical agent. For some time I have also been interested in the invasive (plus uncanny) sensation of the gazes from a whole crowd of machines. *Area V5* followed previous work where I created an array of machines deployed in an arena[22], putting exhibition visitors on stage in front of a synthetic audience in the role of performers and objects of attention.

[22] *L'Assemblée* (2001) deploys 48 robots in a theatrical arena. All the robots are directed and interact towards the central focal point of the structure where the audience is situated.

2.5.1. Description of work

Area V5 is an artistic comment on social robots, particularly on the hypothesis of the role of the gaze in social robotics (Breazeal 2004). I approached the museum theme by re-contextualizing the claims made by recent artificial intelligence work about the prominent role of eye movements in establishing meaningful dialogue between humans and machines.

In this work I explore confluences between the gaze as a non-verbal dialogue facilitating communication between humans and machines and the gaze in the theatre from audience and performers that opens competing perceptual configurations. Writing about spectatorship and the visual field, theatre theorist Stanton Garner discusses the impact of that competition:

> The performer/character's gaze, like the body's living presence that it asserts, exceeds the containing parameters of representational space and confronts the audience's gaze with an intersubjectivity that represents a potential or actual "catastrophe" in terms of spectatorial detachment. From the phenomenological point of view, the living body capable of returning the spectator's gaze presents a methodological dilemma for any theoretical model – like semiotics – that offers to describe performance in "objective" terms. Alone among the elements that constitute the stage's semiotic field, the body is a sign that looks back.. (Garner 1994, p. 49)

The installation-experiment *Area V5* invites the viewer-participant to experience the enigmatic gazes of a massive array of disembodied eyes, a complex act of ambiguous surveillance from silently impotent machines. The mutuality of the gaze, set in train as a strictly positive “mechanism” to enhance man-machine relations, immediately becomes a field of phenomenal interrogation: are eye movements simple reflexes, a common attempt to communicate, a judgment about what unfolds in front of them or a mirror of the machine performer’s “soul”?

The title of the work refers to the visual area V5, a region of the extrastriate visual cortex that is thought to play a major role in the perception of motion, the integration of local motion signals into global percepts and the guidance of specific eye movements.

Figure 26. *Area V5* - Skulls displayed as specimens (Demers 2009-10)
Permission to reproduce this image has been granted by the Musée de la Civilisation.

2.5.2. Area V5 claims and hypothesis

To fully understand the process behind this work, the artefact's design and the scenography of the work, this section presents the premises, claims and underlying investigations determining the development of *Area V5*. The overall question behind the experiment was whether by voluntarily staging an uncanny situation it would percolate through to the visitor.

Clearly the context of the encounter and the audience's expectations are crucial in determining whether an encounter will be experienced as uncanny or not. As this work was intended to become an experiment contributing to the Uncanny Valley section of my thesis, I identified the following related issues from the scientific literature:

1) As most Uncanny Valley experiments modulate morphology and not behaviour, Pollick proposed the following as a worthwhile alternative: "Certainly, one testable claim about Mori's presentation of the Uncanny Valley would be to find an uncanny form and to see if motion can be used to modulate the experience."(Pollick 2007) *Area V5* was designed to generate just such an

uncanny form and determine whether an installation context could actually modulate audience reactions.

2) *Area V5* also sought to corroborate Hanson's statement about modulating the Uncanny Valley effects by means of aesthetics and staging:

> despite the fact that the back of the robot's head was missing so that audiences could see the uncanny robotic interior behind its artificial human-like features […] people who interacted with the robot appeared entertained, not disturbed or afraid. The robot held peoples' attention in conversation for many minutes and even hours. […] 71% said the robot was "not eerie," and 89% "enjoyed" interacting with the robot. (Hanson 2006).

3) Hanson's observations show that audiences can quickly get over initial feelings of uncanniness if they become sufficiently intrigued and engaged by the interactive encounter. It is also possible that the lack of any felt uncanniness in response to Hanson' robot was due to the audience's clear awareness of the robotic nature of the head from the start of the encounter.

4) As Uncanny Valley literature mostly refers to the fear of death as the hidden motive behind the human reactions towards androids (Tondu and Bardou 2011, p. 337), *Area V5* could literally use death to contribute to the uncanny setting. Some proponents of the Uncanny Valley argue that mortality salience contributes to the rejection of the agents (MacDorman 2005). *Area V5* could stage this as an important layer of the artwork.

5) *Area V5* aims to investigate the different levels of the Uncanny as developed by Kang. In these terms, *Area V5* operates under controller parameters, and audience responses should lie within what Kang called the "uncanny sublime".

The voluntary staging of the uncanny could be implemented with various strategies, e.g. literally including elements of death, presenting human morphologies in an uncomfortable way (e.g. surgical or clinical), or creating a space where the visitor is not at ease. The following lists observations and design decisions made in the course of *Area V5*:

1) The scenography of the whole exhibit was organized in a chronological fashion, from the Dark Ages to the present, showing human skulls (e.g. Lucy and Descartes) in almost all sections of this historical track.

2) The scenography of *Area V5* went through several revisions. The initial concept was much more visitor-centred, creating a focal point on the audience. Finally, *Area V5* was organized as a medical artefact display, a long row of specimens one would find, for instance, in a natural history museum (see Figure 27).

3) In the continuity of many of my robotic artworks I am exploring mass replication of the object to study the impact of an anonymous choric member, as opposed to singular and unique entities. Social robotics has mainly dealt so far with singular characters.

4) The linear arrangement of the skulls is analogous to the “skull racks” or Tzompantli found in Mexican culture. These racks were displays of the ritually executed – either war captives or game losers.

5) The skull shape is an exact replica of the human skull, except that is reproduced 50% larger than the original size. The top part of the skull has been truncated with surgical precision and evokes many 3D renderings of medical imagery such as the iconic “visible human project” or MRI scans.

6) The clear skulls are reminiscent of the iconic “visible man” anatomic model (1960s-70s) where the skin becomes a transparent plastic layer revealing the inner constituents of the human body.

7) The sliced skulls are also a pastiche of the mechanistic Cartesian view of the body: the audience can freely see the internal mechanisms that generate eye movements, and the body of the agents is reduced to the skull, the repository of the brain and hence of the Cartesian intelligence.

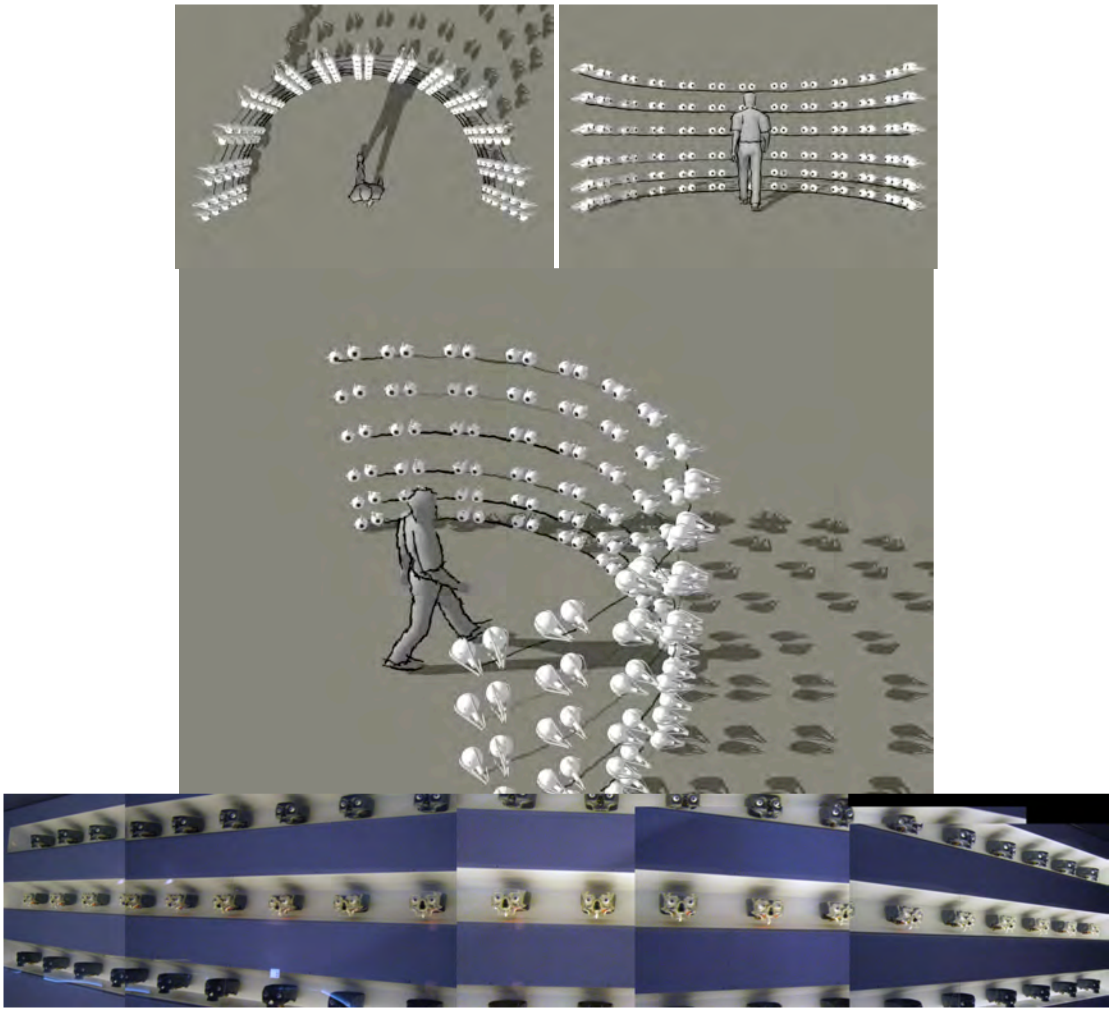

Figure 27. *Area V5 (Demers 2009-10)*- initial proposal (above) and final linear layout (below)

2.5.3. Technical details

Area V5 is a large-scale interactive installation comprising sixty mechatronic human-like skulls retrofitted with moving eyes. The eyes are capable of following the movements of the audience, and track faces among the participants. *Area V5* is three metres high and ten metres long. The sixty skulls are laid out in three rows of twenty skulls each.

My initial idea was to construct a biomorphic object as close as possible to the human skeletomuscular system using artificial muscles[23], on the assumption that a stronger sensation of the uncanny would emanate from what resembled a display of

[23] McKibben actuators are inflatable chambers that expand and contract in a similar fashion to an organic muscle.

organic matter brought alive than from an array of obviously mechanical displays. Each eye has six muscles that control its movements. When the muscles exert different tensions, a torque is exerted on the eye globe that causes it to turn and position itself. This is an almost pure rotation about a single point in the centre of the eye.

Unfortunately, as I wanted to study the experiential impact of the space formed by a robot crowd, the economic feasibility of the eyes' implementation became important. So I had to depart from verisimilitude in the look of the eyes towards simpler pan and tilt gimbals that could mimic a wide range of possible eye movements (see Figure 28). The gimbals actually did implement a rotation around the centre of the eye, though electro-mechanical movement is not as fluid as that derived from an artificial muscle.

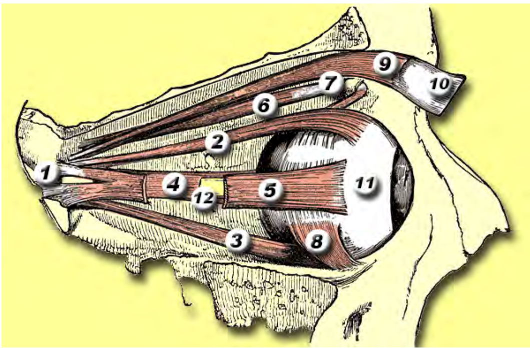

Figure 28. Eye's skeletomuscular system and pan-&-tilt gimbals (Demers 2009-10)
Permission to reproduce the left image has been granted by the Creative Commons.

Mass-producing sixty copies is a large undertaking. First, even if the skull's proportions are slightly blown up, the need for miniature mechanisms is a major challenge. I had to rely on computer models and CNC manufacturing to make and assemble small mechanical linkages. Second, the carbon copy of the skulls was achieved by purchasing a 3D model of a digitally scanned human head. Afterwards, this computer model was altered (cutting a section, removing the jaw) and treated to feed into a 3D rapid prototyping device. This precision sculpted piece of plastic was then used as a positive mould to cast all the skulls. Both of these steps meant a radical change from my usual design and production process for machine performers. Up to then I had used crude bolted, welded and powerful structures, hand made out of metal and pneumatic muscles. *Area V5* made me shift to small, fragile motors and plastic parts designed on the computer then assembled with glue, like the robotic toys and pets found in the commercial world.

Evoking the eye movements of humans relies on four basic motion characteristics: saccade, pursuit, vestibulo-ocular reflex and vergence. Saccades are rapid ballistic eye movements jumping around the visual field locating interesting parts of the scene. Pursuit is the tracking movement that smoothly follows a moving target. The vestibulo-ocular reflex maintains eye fixation on a target while the head and torso are moving. Vergence is the ability of the eyes to converge towards or away from each other in order to focus on an object. Vergence obtains or maintains binocular vision. Seen from the outside, a person can spatially determine with accuracy where the eyes are looking. However, the vestibulo-ocular reflex involves costly extra degrees of freedom (the whole skull would have to move), so this motion could not be part of *Area V5*'s repertoire.

Building non-verbal dialogue between audience and skull(s) relies on the dynamic aspects of eye movement, such as staring versus glancing or engaging with eye contact. In order to "see and detect" the audience, cameras are installed in each skull in the middle row. As the exact position of every skull in the array is known, eye movements can be calculated and programmed for neighbouring skulls (above and below) even if the camera is on a remote skull. The locus of attention can be detected from each visual input in the form of the fastest or largest optical flow activity in the camera's image. This enables faces to be recognized as such along the approximate line of their eyes.

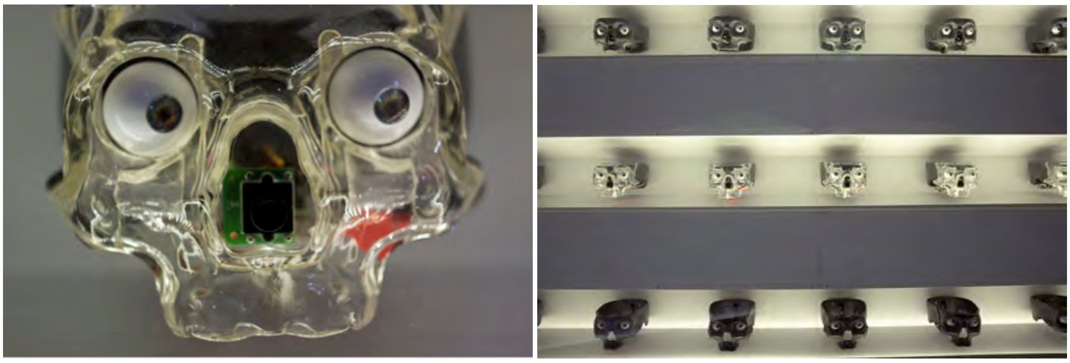

Figure 29. *Area V5* - skull close-up and multiple gazes (Demers 2009-10)

Interpreting the motion detection data that control the eye movement characteristics mimics a dialogue. For instance, sometimes the mechanical eyes saccade from one salient point of motion to another, sometimes they stare into the void awaiting an audience and sometimes they follow someone's face until their attention is captured by another person's waving hand. Equipped with a vast array of skulls, one set of eyes could be following a person's hand while the next one stares them in the eye. Such multiple focuses have not been previously studied in social robotics, as most of the experiments deal with a one-on-one situation (or sometimes a many-to-one robot situation).

2.5.4. Comparative works

In this section, I will compare three similar artworks utilizing gaze as a central concept, and discuss two social robots, *Kismet* and *Keepon* – two icons of the role of shared attention through eye movement in social robotics.

1) *Kismet* (Breazeal, 2000)

Roboticist Cynthia Breazeal developed *Kismet* at the MIT's AI lab (Breazeal, Brooks et al. 2003, p. 167; Breazeal 2004). *Kismet* aims to engage people in a face-to-face interaction with the help of social cues from auditory and visual channels. *Kismet* delivers back its own social cues with gaze and facial expressions. These human-machine social cues are all based on human social cues. On top of replicating human movements (for instance saccades), *Kismet* possesses mechanisms of shared attention built upon eye movements, such as the deictic gaze of recognition, or maintenance of eye contact. *Kismet* vests intentionality in the participant by establishing the implicit postulate that the shared locus of attention reveals what the participant currently considers behaviourally relevant. In turn, the participant will (in many cases) vest intentionality in this mechanical agent under the same conditions.

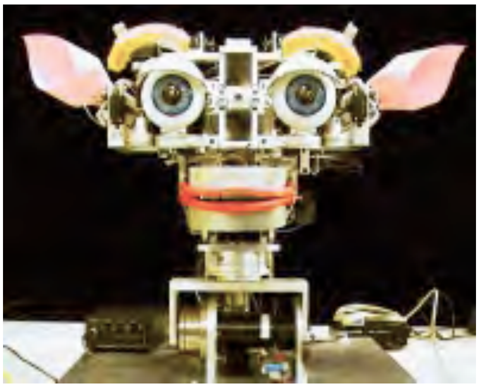

Figure 30. *Kismet* (Breazeal 2003)
Permission to reproduce this image has been granted by Elsevier.

2) *Keepon* (Kozima, 2009)

Keepon is a small robot designed for minimal non-verbal communication with children. *Keepon* does not move its eyes towards a target but moves its whole body instead. In what Kozima labels as attentive action, it can gaze at an object and generate shared attention with the person. *Keepon* also has emotive action where it can squish and rock its body to give the impression of expressing an internal state, mostly pleasure and excitement.

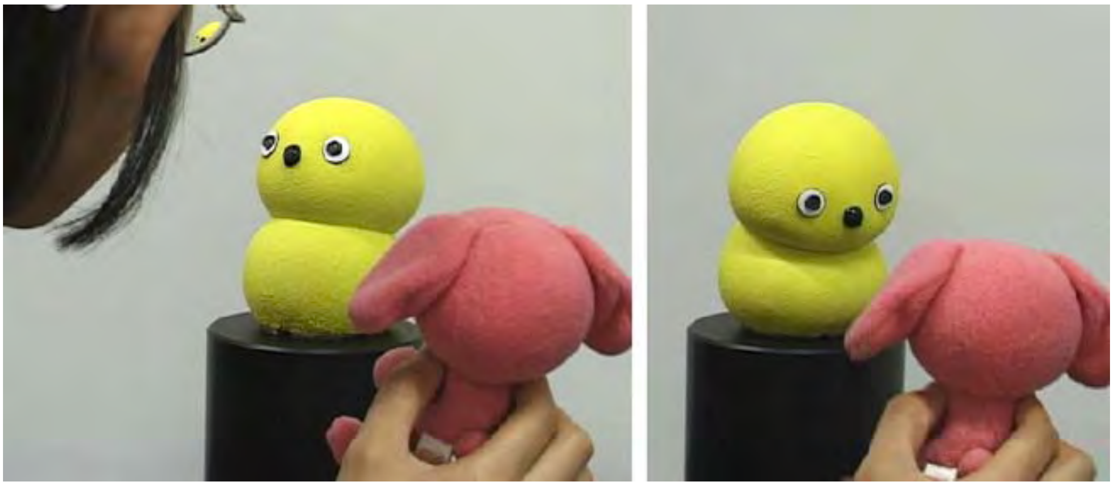

Figure 31. *Keepon* (Kozima, Michalowski et al. 2009)
Permission to reproduce these images has been granted by RightsLink (Springer).

3) *Opto-Isolator* (Levin & Baltus, 2007).

According to Golan Levin and Greg Baltus, the authors of *Opto-Isolator*, the sculpture inverts the condition of spectatorship: "What if artworks could know how we were looking at them? And, given this knowledge, how might they respond to us?" (Levin and Baltus 2007). The piece presents a solitary mechatronic blinking eye that responds to the gaze of the visitor with what they describe as "eye contact behaviours that are at once familiar and unnerving". *Opto-Isolator* has elaborate eye contact feedbacks such as mimicking visitor's blinks and looking away after a sustained stare.

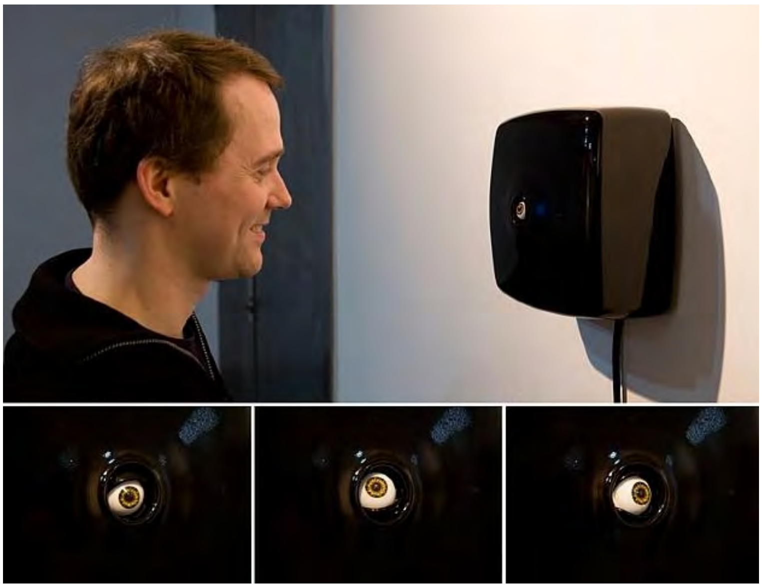

Figure 32. *Opto-Isolator* (Levin and Baltus, 2007)
Permission to reproduce these images has been granted by the artitsts.

4) *Desire of Codes* (Seiko Mikami, 2010)

The installation *Desire of Codes* consists of three different parts responding to the movements of the audience: a large wall of sensors, a set of moving cameras, and a video display compounding images in the manner of insect vision. Again this work draws on the reversal of roles of object and subject and from the commissioners of this piece:

> Audience who experience this artwork stands face to face with his or her own observed and encoded existence, the resulting data/codes, and ultimately, the repercussions of "the body as data" and "the desire of codes." [...] By turning the audiences bodies into both the objects of observation and artistic expression, this work aims to redefine our position in a time when all kinds of environments – including those of everyday life – are increasingly being information oriented society. (Mikami 2010) [*sic*]

Referring heavily to sensory perception, the "wriggling wall" comprises 90 units that behave like some kind of insect's antennas. The stated purpose of this massive device is to turn an entire inorganic apparatus into a living being reacting to the motion detected in the exhibition space. The difference between *Desire of Codes* and other works reported here is that the audience is presented with what the device captures by recombining the data fragments into a projection surface representing an insect eye.

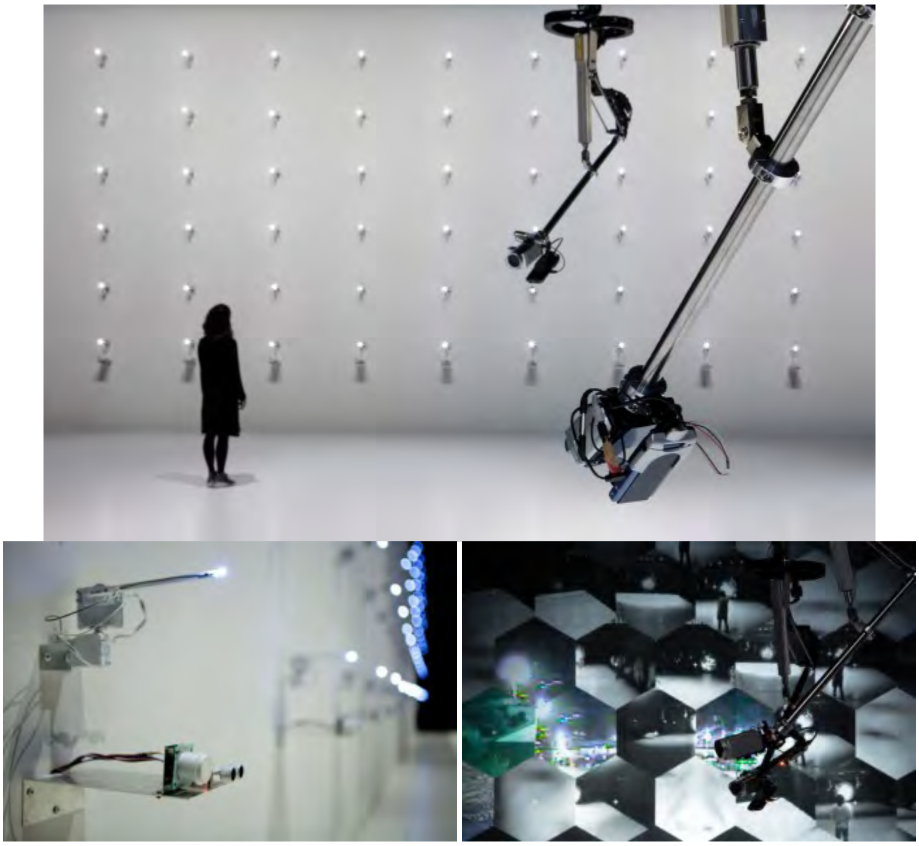

Figure 33. *Desire of Codes* (Mikami 2010)
Permission to reproduce these images has been granted by the artist.

5) *Zeugen* (Morgan Rauscher, 2009/10)

In his description of his work Rauscher also raises the question of spectatorship:

> I question who owns the 'visual' experience in this gallery space. What is the spectacle and 'who' is the spectator? Do we passively witness or are we also witnesses of ourselves by the act of witnessing? A struggle is revealed causing tension between the witnessing and the witnessed. […] I find the sensation of 'vision' to be moving in both directions simultaneously between the viewer and the viewed. (Rauscher 2009)

Zeugen, a German word meaning "to witness" or "witnesses", is also a large array of staring eyes, but for this piece full faces are cast and embedded in a wall. The system also relies on face tracking; however *Zeugen*, in contrast to *Area V5* and *Opto-Isolator*, utilizes an ambient soundtrack.

Rauscher claims that: "Viewers of the work experience a powerful visceral event and are motivated to interact and play with the work." In his thesis, Rauscher mentions that the mechanisms were originally hidden from the visitor, but he observed that people looked "behind the wall" to find them. Rauscher then made versions that would reveal the construction (Rauscher 2010).

Figure 34. *Zeugen* (Rauscher 2009-10)
Permission to reproduce these images has been granted by the artist.

All the artworks featured here share a reversal of situation in which the audience is sensed and observed. I have brought the two social robots *Kismet* and *Keepon* into the comparison to contrast their aims with those of the four artworks. The social robots evidently attempt a friendlier appearance than the objects made by the artists. The non-verbal dialogue of *Keepon* feels animate, whereas the facial and head expressions of *Kismet* feel animated and constructed. *Keepon*'s body gestures are aligned with its morphology and this makes it credible in its reduced set of expressions. In general, social robots playact – almost overacting – at being zoomorphic agents. As Kang remarks about the amusement that arises from robots:

> Our attention is arrested by the device because it tries to cross the boundaries of animate/inanimate, natural/artificial, living/dead, but it does such a bad job of it that it ends up reaffirming our normal schema of reality. And so we laugh in relief at its failure and domesticate the object in terms of childhood playfulness, finding it amusing and cute. (Kang 2009, p. 53)

The gazing robots of the artworks, constrained to a smaller range of behaviours than the two social robots, play on the fine line between being entertaining and being disconcerting. In all cases, the robots are presented as mechanical, sparking a sense of playfulness from the dialogue with the gazing eye(s). But their unbroken gaze creates a sense of indefinable and discomfiting judgment. In these situations, the uncanny does not emanate from the flaw of not achieving a verisimilar sense of life but from the achievement of presenting and mimicking a behaviour (gaze) that is, in turn, modulated by the aesthetics of the object and the scenography of the space.

In line with Kang, where he introduces the notion of the sublime into his Uncanny Valley analysis – "we feel awe rather than amusement in front of the great, powerful machine […], the same way as at the sight of a grand view of nature"(Kang 2009, p. 54) – my claim is that regardless of the quality of the dialogue inherent in the mutual gaze of audience and robot, its space and scale can enhance the sensation of either the uncanny or the technological sublime.

Applying this to the works under consideration here, I would see *Area V5*, which distinguishes itself from the other artworks by its voluntary staging of a large number of dead specimens, as targeting the uncanny sublime. In comparison, *Zeugen* enacts a sense of enumeration found in large pixel displays rather than a dramatic organization, and in that respect tends towards the technological sublime. The awe engendered by the large-scale organic *Desire of Codes*, with its elaborate tentacle array, emerges from a mass of mechanical entities and also has its roots in the technological sublime. Table 8 provides a summary comparison of the works presented in this section.

In the following section, I will analyse the results of a survey conducted about audience emotional reactions from experiencing *Area V5*. I will further argue for the role of scenography to trigger the uncanny. I will also differentiate the entertaining from the disconcerting and from the uncanny sensations inside *Area V5*'s audience experiences.

	V5	*Opto*	*Zeugen*	*Desire Codes*	**Social Bots**
Gaze.	Many too many.	Dialogue is one on one. Bystander can witness.	Many too many.	Many too many.	Dialogue is one on one. Bystander can witness. *Keepon* demonstrates that a reduced set of movements can still lead to a large array of behaviours.
Immersion scenography	Yes. Uncanny is also a scenographic goal.	No object	In-between. Many units put together in one display.	Yes. Scenography brings fascination with wriggling wall.	Laboratory as mise-en-scene. Not meant to have an impact.
Uncanny setting	Clinical display of skulls.	Cyclops as unreal chimerical object.	Display recalls more pixels than human faces.	Massive array of sensors.	Aim at not being uncanny, as both objects are designed to be friendly.
Kang's model. **All works stay within controlled parameters.**	Amusement - sublime.	Amusement -uncanny.	Amusement -uncanny sublime.	Amusement - uncanny sublime.	*Kismet* (grotesque) *Keepon* (pleasure)
Animate / **Animated**	Survey shows more animated than animate.	Animate	Animated	Animate (wriggling wall). Animated for their components.	*Kismet* – Animated due to its cartoonish features. *Keepon* – Animate due to its effective body language.

Table 8. Summary comparison of gaze and space aspects

2.5.5. Data collection and survey analysis

Area V5 was first presented at the Museum of Civilization in Quebec City in the context of a major exhibition on Human Copyright from November 2009 to September 2010. The following year, *Area V5* was also included in the HUMAN+ exhibition at the Science Gallery (Dublin) from March to June 2011 (Armstrong

Rachel , Spillane Charles et al. 2011). During the exhibition at the Science Gallery, gallery staff distributed surveys over a period of two weeks and I collected around fifty completed questionnaires. The staff ware instructed to first let the visitor experience the work freely and then voluntarily complete the forms. No time limit was assigned to the experience. Staff were also instructed that other visitors should not influence respondents.

Aimed at establishing the audience's associative emotional response to *Area V5*, the survey dispensed with bipolar scales of affinity like those found in the Godspeed questionnaire (Bartneck, Kulić et al. 2009). Instead, respondents were asked to rate the impact of several characteristics that could contribute to such oppositions. For instance, questions such as "Please rate your impression of the robot on these scales" usually offer scales with poles that implicitly oppose man and machine such as, machinelike vs. humanlike, unconscious vs. conscious, or mechanical vs. organic. The *AreaV5* survey broke down such antinomies by asking respondents to rate the poles separately: "Did the robots feel mechanical?", "Did the robots feel organic?", "Did the robots feel conscious?" Furthermore, there were no questions that addressed the Uncanny Valley directly or that utilized words typically found in scientific surveys in this field. For instance, the words 'uncanny' and 'anthropomorphism' did not appear in the survey.

The survey was succinct – only three pages long – and gathered information about respondents' knowledge and experience of robots, their reactions and impressions to *Area V5*, and additional demographic data. The data relating to audience reaction was measured on a ten point Likert scale (e.g. from no impression to strong impression).

1) Audience reactions

The first question, "How did you feel when you first encountered the work?" was to evaluate if audience impressions tended more to the amusement/entertainment or unfamiliar/uncomfortable side. The question asked the audience to rate six emotional states as reported by the box plot of Figure 35.

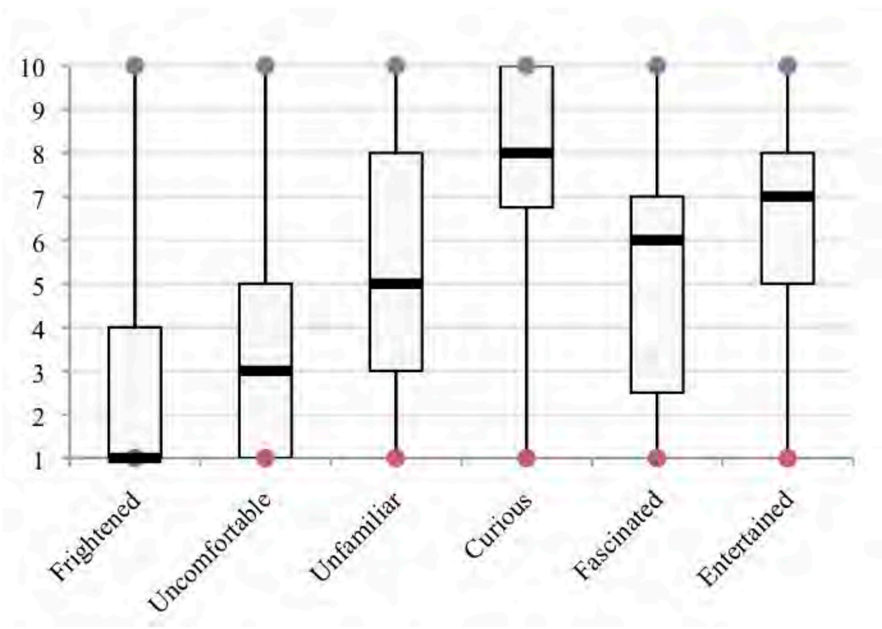

Figure 35. Box Plot – *Area V5* audience reactions

The measured intensity is significantly different across the range of emotion surveyed X^2 (5) = 82.09, p<0.5 (Friedman's Anova). Wilcoxon's tests were used to perform follow-up analysis of this result and verify if people felt significantly more entertained and curious than frightened, unfamiliar with the set-up or uncomfortable. A Bonferroni correction had to be applied in order to compare the match-ups between frightened, unfamiliar and uncomfortable with a control (either entertained, fascinated or curious), i.e. a level of significance of 0.016 instead of 0.05 (divided by 3).

	Frightened	Uncomfortable	Unfamiliar
Entertained	N=55, T = 181.5, Z=4.621, p= 0.	N=56, T=353., Z=3.059, p=0.0022	N=55,T=415., Z=1.774, p=0.076
Fascinated	N=55, T=242.5, Z=3.94154, p=0.00008	N=55, T-408.0, Z=2.22,p=0.0267	N=55, T=552.5, Z=0.597, p=0.551
Curious	N=55, T=78.5, Z=5.55977, p=-0.	N=56, T=201.5, Z=4.4396,p=0.00001	N=55,T=262., Z=3.487, p=0.00049

Table 9. Follow-up analysis – comparison of affinity

Viewers evidently felt significantly more curious than frightened by, or uncomfortable or unfamiliar with the installation set-up (all p<0.016, see Table 9).

They also felt significantly more fascinated than frightened (p=0.00008) but not more so than unfamiliar. They felt almost more fascinated than uncomfortable but just failed to establish this as significant due to the correction. Finally, they felt significantly more entertained than frightened or uncomfortable (p=0. and p=0.0022 respectively). However, the analysis indicated that their sense of being entertained was not significantly greater than their sense of unfamiliarity when confronted by such an array of robotic skulls. The second question – "How do you feel about the reactions the skulls have toward you, do they feel…" – was to rate five qualities of the behaviour of the skulls (see box plot of Figure 36). The third question – "What creates an impression on you?" – tried to locate some of the criteria utilized in the skull behaviour assessment and also overall impressions of the installation (see boxplot of Figure 37).

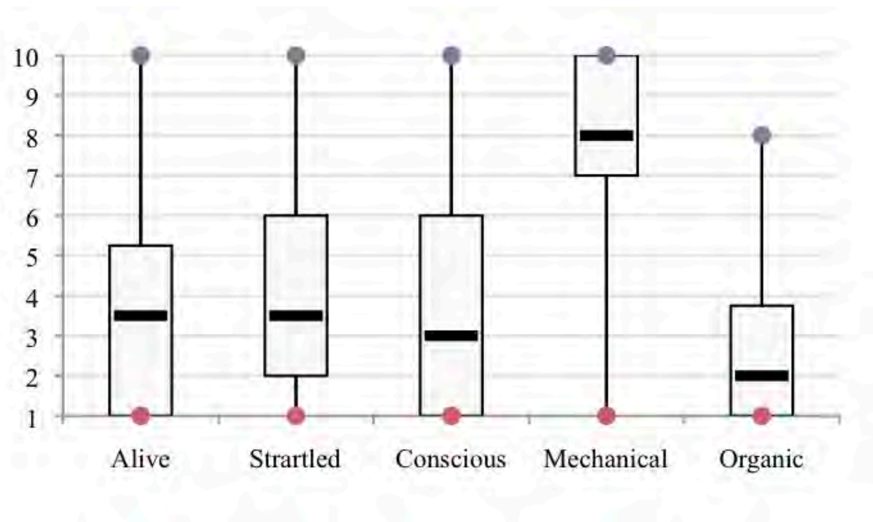

Figure 36. Box plot – *Area V5* skull behaviour perception

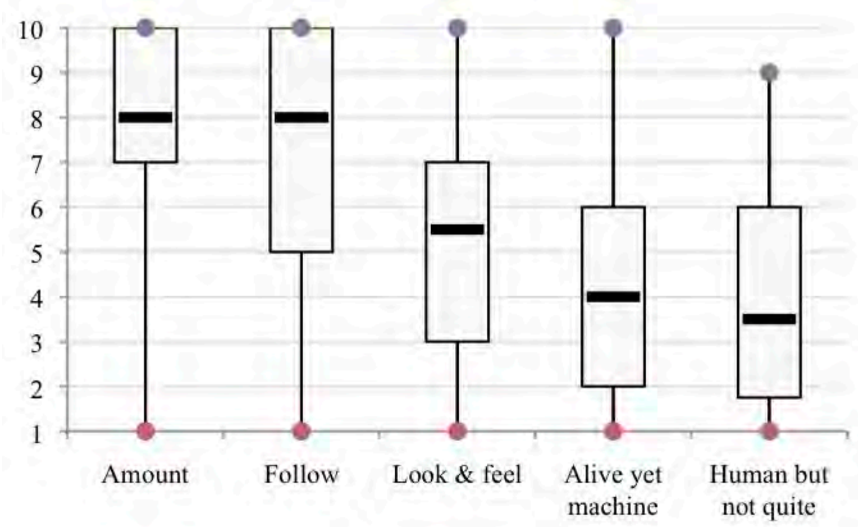

Figure 37. Box plot – *Area V5* impact on audience

A majority of participants clearly found that the skulls of *Area V5* felt mechanical rather than organic, startled, alive or conscious. Consistently with this, they did not consider the quasi-living dissonance as very impactful, although the measured intensity was significantly different across the range of impact surveyed X^2 (4) = 72.12, p<0 (Friedman's Anova). I further looked at the impact of the number of skulls and their tracking capacities as opposed to just their look and feel. The number and the eyes' tracking feature were reported significantly more impactful than the aesthetics of the skull, scoring respectively N=55, T=109, Z=5.008, p=0, and N=56,T=151.5, Z=3.882 and p=0.0001 in Wilcoxon tests.

The fourth question – "Is it important that they behave like humans?" – concealed one of the motifs of the Uncanny Valley, i.e. is movement more important than form? The box plot of Figure 38 measures three characteristics of the skulls: the way they look, the way the eyes move (at large) and the way they follow a person. The measured importance was significantly different across the range of characteristics surveyed with X^2 (2) = 8.378, p<0.015 (Friedman's Anova). A follow-up analysis with Wilcoxon tests revealed that the general eye movement was significantly more important than the look of the skulls (N=55, T=105.0, Z=2.622, p=0.0087) while the specific eye pursuit failed to significantly surpass the aesthetics of skulls (N=55, T=201.5, Z=1.64, p=0.100).

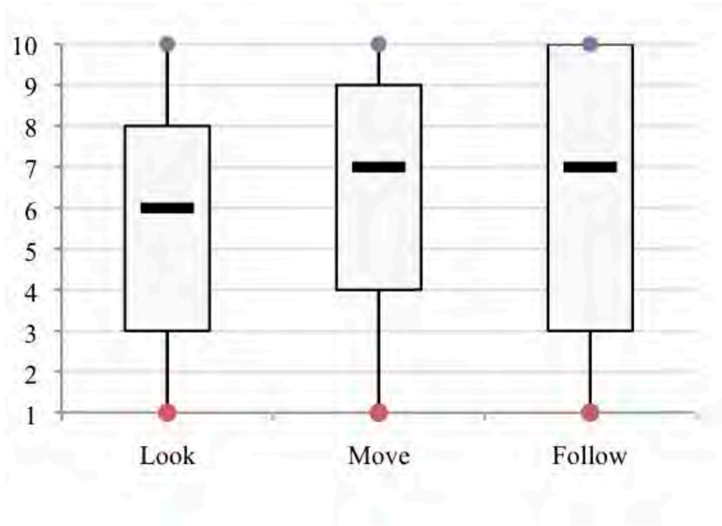

Figure 38. Box plot – *Area V5* human-like behaviour

The fifth and last question was a hidden control question: “Would you have a skull installed in your house and looking at you?” By telling whether or not they would share a more personal social interaction with a skull, audiences were indicating their affinity or sense of amusement or entertainment with the behaviour and look of the skulls. Among the surveyed visitors, 25% of them replied that they would have a skull at home.

In an attempt to correlate under what conditions individual viewers felt frightened, uncomfortable or unfamiliar, I looked into Pearson correlation factors. Even though none of these sensations were strongly measured in audience reactions, it was worth looking at their root, especially for the unfamiliar state, since it stood in the middle of the appreciation scales. The summary of the results is reported in Table 10 and they indicate the variation of sensations from *Area V5*.

When visitors feel uncomfortable, there is a strong relationship with considering the skulls alive (R=0.53, p=0.0001) and a moderate relationship with considering them conscious (R=0.36, p=0.013). I can consider that being gazed at and judged by living beings makes me uncomfortable. The characteristics related to this uncomfortable sensation are moderately linked to the skulls’ pursuit of the spectators and weakly influenced by the number of skulls (R=0.32, p=0.02 and R=0.25, p=0.05).

When visitors feel frightened, the relation with considering the skulls alive is strong (R=0.59, p=0.00002) and the impact of this nervous crowd of skulls is moderately linked to this sensation (R=0.34, p=0.02). The characteristics shift to the quasi-living status of the skulls when the alive and the not-quite-living perceptions are moderately rated (R=0.37, p=0.007 in both cases). The frightening sensation seems to be rooted in psychological observations, the quasi-living, typically found in Uncanny Valley literature.

Finally, the sensation of unfamiliarity could not be moderately correlated to any perceived behaviour of the audience. However, the number of skulls and their pursuit do moderately contribute to this sensation (R=0.38, p=0.005, R=0.31, p=0.02). Unfamiliarity seems more based on the unusual confrontation with a mass of gazing objects.

	Pearson's R (N=47)	p-value
Alive vs. Uncomfortable	0.53259	0.00012
Conscious vs. Uncomfortable	0.36134	0.01258
Startled vs. Uncomfortable	0.19687	0.18473
Mechanical vs. Uncomfortable	0.14904	0.31737
Organic vs. Uncomfortable	0.06455	0.66642

	Pearson's R (N=55)	p-value
Follow vs. Uncomfortable	0.32426	0.01573
Amount vs. Uncomfortable	0.25962	0.05561
Look & Feel vs. Uncomfortable	0.23306	0.08683
Alive vs. Uncomfortable	0.12538	0.36172
Not quite alive vs. Uncomfortable	0.01842	0.8938

	Pearson's R (N=46)	p-value
Alive vs. Frightened	0.58829	0.00002
Startled vs. Frightened	0.33981	0.02086
Conscious vs. Frightened	0.19232	0.20038
Mechanical vs. Frightened	-0.15133	0.31542
Organic vs. Frightened	0.1314	0.38404

	Pearson's R (N=54)	p-value
Not quite alive vs. Frightened	0.36778	0.00622
Alive vs. Frightened	0.36767	0.00624
Look & feel vs. Frightened	0.23488	0.08733
Follow vs. Frightened	0.18701	0.17571
Amount vs. Frightened	0.14434	0.29772
Not quite alive vs. Amount	0.06911	

	Pearson's R (N=47)	p-value
Mechanical vs. Unfamiliar	0.23247	0.11584
Conscious vs. Unfamiliar	0.22523	0.12797
Alive vs. Unfamiliar	0.22348	0.13105
Startled vs. Unfamiliar	0.15773	0.28965
Organic vs. Unfamiliar	-0.02508	0.8671
	Pearson's R (N=54)	p-value
Amount vs. Unfamiliar	0.38064	0.00452
Follow vs. Unfamiliar	0.31058	0.02227
Not quite alive vs. Unfamiliar	0.21736	0.11438
Alive vs. Unfamiliar	0.20855	0.13019
Look & feel vs. Unfamiliar	0.01326	0.92417

Table 10. Pearson's correlations for 'uncomfortable', 'frightened' and 'unfamiliar'

In order to verify the correlation data I ranked answers into quartiles to create sub-groups among the participants. The abnormal data distribution suggested the existence of such sub-groups. For instance, instead of looking at the whole population, I could look only at the top 25% of respondents (the most frightened people per se) and see if this related to any other factors. The results of the correlation concur with this ranking. For instance, Figure 39 shows the box plots of three factors surrounding the unfamiliar sensation. If I compare the extreme groups, i.e. low 25% and high 25%, I obtain a significant difference between the two groups ($p<0.05$). In other words, the most unfamiliar persons in the surveys were also the most impressed by the pursuit, the number of skulls and their perceived consciousness. I did not find any discrepancies between the correlation and this quartile ranking method.

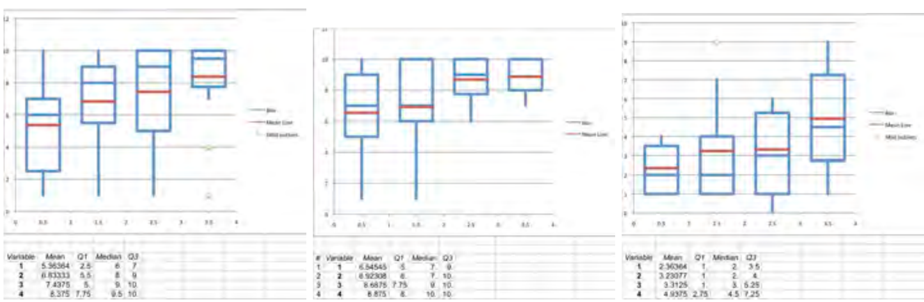

Figure 39. Box plot of unfamiliar quartiles vs. tracking, number and consciousness

2) Demographics and general information

The opening questions of the survey were designed to gain a picture of the participant's views or conceptions of what is a robot. They were briefly confronted with many versions of real and fictitious robots and were asked to rank each of these as qualifying to be considered a robot. The box plot of Figure 40 reports the various representative types and their success rate.

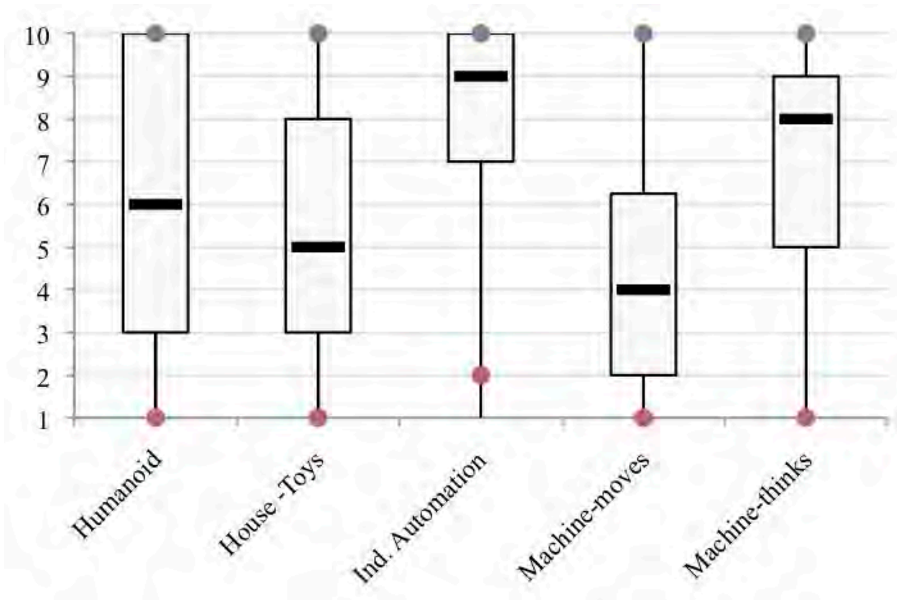

Figure 40. *Area V5* – What is a robot for you?

3) Discussion

The results show that for the respondents to this survey a robot is more a machine-that-thinks than a machine-that-moves. This agrees with the Cartesian view of the old AI, but nonetheless provides hints about where they situate the roots of robotic behaviours and intentions. The industrial robot surprisingly surpasses the archetype of autonomous robots: the humanoid. This probably indicates that this audience was well aware of the unexciting reality of most mechanical agents. In both cases, it indicates that the concept of nouvelle AI has not reached a broad public.

Although *AreaV5* is a clear reference to death (of which the skull is the icon par excellence), the main result of the survey is that I can quantitatively demonstrate that visitors feel neither scared, nor uncomfortable nor unfamiliar but rather entertained and curious. This situates their experience, following Kang's chart, at the Uncanny Sublime.

According to Hanson, art can modulate aesthetics and facilitate acceptance of the agents by participants. But perhaps the death references are too direct in this instance and the skulls too mechanical. The skulls are bodiless and skinless, a clear representation of a mechanical artefact. Nonetheless those who found them most disconcerting also judged them "conscious" inasmuch as they conveyed a sense of surveillance. The discomfiting sensation emanates from the perception of the skulls being alive, from their tracking pursuit of the viewer-participant, not from their looks. This is in accordance with Mori's assertion of the prevalence of movement over anthropomorphism.

It is clear that the audience did not find the robots of *Area V5* markedly "alive" but this did not prevent them from being curious and entertained. After all, the object's mechatronics are not concealed, which gives it a strong animated and mechanical flavour. Nonetheless, the skull's capacity to follow and react to audience movements did radiate enough consciousness to generate some levels of discomfort.

Hence it can justifiably be said that *Area V5* modulated an uncanny situation, translating the anthropomorphic uncanny in the sight of animated (but manifestly dead) skulls into an entertaining (and sublime) experience. Forgetting the essentially representative nature of these moving eyes, they become articulated mirrors, and the audience shifts its attention to their narcissistic movements. Audiences can sidestep the uncanny setting and initiate a different mode of experience by transferring their focus from the intentionality to the functionality of the robotic skulls. Doing so, they will no longer consider the agent an uncomfortable presence (haunting souls looking at me), and their own gaze will transform into a playful challenge to the visual reflexes of these mechanical creatures. We may conclude, therefore, that the initial concept of *Area V5*'s scenography (an uncanny-sublime environment) is impactful but fails to create an overwhelming (and hence unambiguous) sensation for the viewer. However, the sense of the sublime engendered by the scenography evidently succeeded in making the audience curious and enriched their experience in the dimension of entertainment.

By letting the audience navigate within these levels of representation – the automaton gazing as a simple, but in this instance simply disruptive, function of a conscious mind "accepting" my own gaze – the cognitive dissonance is lessened to a level of marginality or even non-existence. The presence of the skulls implies, but at the same time denies, a perceived intentionality in these pursuing eyeballs. If a visitor considers the environment as animate, he/she will become uncomfortable. If a visitor considers the environment as simply animated, it will remain entertaining. In the case of *Area V5*, audience perception has oscillated between the animate (and hence intentional) and the animated (and hence functional). In leaning towards the animated it has effectively distanced itself from the aesthetic realm of the uncanny and entered that of the playful and entertaining.

2.6. Conclusion

By analysing, comparing and regrouping several discussions on the Uncanny Valley, I have shown that the concept is ill-formed and shallow. The focus on the word "uncanny" itself misguides robotic research in its discussion of the valley. And some promoters of androids not only misrepresent the real meaning of anthropomorphism, they also shift public attention from relevant agency and social behaviours to the verisimilitude of visual cues (hair, skin) and motion cues (details of eye movement, smoothness of motion). The most prominent examples of the Uncanny Valley in the scientific world are uncanny not because they follow or diverge from Mori's law, but because they enact broader psychological dualisms and schisms: the evil twins (geminoids), the superficial genderising and casting of objects (actroids) and the utopian love of perfect partners.

Nonetheless, the developers of androids utilize the Uncanny Valley as a pseudo-scientific justification for their undertakings (MacDorman and Ishiguro 2006). The hidden quest for verisimilitude in developing a human carbon copy is shadowed by the argumentation that, by building a copy of ourselves, we have a functional entity to test incarnate models of social behaviour and cognition, to name a few of the reasons given for this research. These undertakings are questioned by Kaplan: "Robotic experimentations sometimes give the impression of being only a dramatization, linking with modes of presentation found in public scientific demonstration dating from the 18th century; stagings of science without real epistemological stakes" (Kaplan and Oudeyer 2008, p. 288)

The current formulation of the Uncanny Valley is not about embodiment. Actually it conveys a tacit rejection of any other morphology than human as a gauge for social robotics. Seeking for the facsimile funnels the vision and diverts from the potential of alternative behaviours and morphologies.

In order to expand on the issues raised by this thesis and to determine whether it can apply to the case of the machine performer, I needed to re-situate attention from morphology alone to the tandem of morphology and behaviour. Only this provides a complete picture. As humanoids and robots derived from engineering are built for understanding and not for shifting or playing with viewer perceptions, artistic explorations of the Uncanny Valley and their analysis are not generally allowed to contribute to the dilemma, where they might provide alternative views and evidence (see Table 11).

By conducting a qualitative analysis of various attempts to model the Uncanny Valley, I have been able to establish that the phenomenon can be reformulated on the basis of "multi-stability perception" in the audience, a model expounded for theatre performances by Fischer-Lichte (Fischer-Lichte 2008; Fischer-Lichte 2008). The liminal divide found in the Uncanny Valley corresponds to the multi-stable perception of performers from an audience, constantly shifting back and forth from pretence to presence. This multistability is an accepted, even empowered, state in theatre.

By playing a role between representation and embodiment, the animated and the animate, the automatic and the agentic, the machine performer can explore some of the disturbing ambiguities associated with the machine's uncanny lack of credible agency. In this chapter I have argued that the Uncanny Valley – or the breach in the suspension of disbelief – might lie where perceptions start oscillating between the function (automatic) and the intention (agentic), the inert/mechanical and the quasi-life qualities, of the robot. Too many oscillations over time may cause confusion and ensuing loss of identification. Festinger's theory that qualifies machine performers qualitatively with strong or weak dissonance is also applicable here.

In my practical works, exemplified by *Area V5*, the Uncanny Valley does not manifest itself strongly at all. Although in these works the topics presented are sometimes distinctly uncomfortable (intimate touch, surveillance, malformed bodies), audience feedback indicates a willingness to engage with the artwork. The Uncanny Valley of *Area V5* was from its inception considered an aesthetic stand, and viewer response shows that it can be accepted as such, and even found entertaining, like any other unusual environment.

To conclude, I will not look upon the Uncanny Valley in the following chapters as a measure of whether a machine performer is credible to (or accepted by) an audience. I will continue to apply the gauge of the animate vs. animated and I will argue that a salient characteristic of a positive evaluation is a "strong stage presence". This strong stage presence will be developed and defined in the next two chapters, following the tandem morphology/behaviour mentioned above, first from within the machine performer via embodiment perspectives, and secondly from the outside, by looking at mechanisms of perception, reception and identification of mechanical agents.

Science	**Art / Theatre**
Identification Familiarisation Repetition/Reproduction	Alienation Defamiliarisation Ostranenie
Engagement	Entertainment
Invariant context to isolate experimental variables	Situated, contextualised and codified
Aims to understand the human by building copies	Aims to understand humans by staging situations
Performative (functionality)	Interpretive (intentionality, presence)
Autonomous agent	Exists with co-presence of the audience
Quest for affinity	Cognitive dissonance is an aesthetic experience.
Quest for perfect replica (morphology)	Metaphors, abstractions, alterations
Quest for perfect replica (behaviour)	Exaggerated behaviours - camp (Dixon)

Table 11. Résumé of science vs. art strategies (for the Uncanny)

3
Comparing Embodiments

3.1. Outline of chapter

The role of the body in relation to human intelligence is now at the forefront of research in artificial intelligence, philosophy, psychology and neuroscience. For example in the seminal book *Phenomenology of Perception*, philosopher Maurice Merleau-Ponty argues that the human perceives and conceptualizes everything though the body. Furthermore, he posits that human consciousness is embodied, eradicating the separation of mind from body (Merleau-Ponty 1962). This school of thought has been embraced by recent bottom-up approaches found in nouvelle artificial intelligence. By understanding their view on the role of the body in intelligence, I will explore and adapt their fundamental results to develop new perspectives. In fact my aim is to design morphologies and implement behaviours for *machine performers* so that they become embodied agents on the stage itself. In this way I will attempt to contextualize *machine performers*, inscribing them with an historical body and to expand the rather restrictive notion of embodiment in artificial intelligence.

While these nouvelle attitudes of embodiment in AI have challenged the Cartesian and orderly juxtaposition of the brain, the body and its interaction with the environment, Rolf Pfeifer still suggests in his latest book *How the Body Shapes the Way We Think*, that AI should continue to focus on non-hierarchical links between the brain (the computer) and the body as an eloquent distribution of muscular control mechanisms and cognition. For example, he suggests that walking is revealed to be a combination of the materials (tissues, bones, flexibility, sensors) and of distributed processing between the body and the brain. (Pfeifer, Bongard et al. 2007)

In my opinion, these concepts of the physical body as analogous to a biological organism and the environment as analogous to a physical terrain are too narrow, and I would suggest that a richer multi-layered conception of embodiment would be appropriate in AI. From my conversations with scientists, I have concluded that many AI researchers sadly underestimate the concept of embodiment inside the theatre environment. In this chapter, I suggest that the relation between basic human movement and robotic movement might benefit from simultaneous comparison on a metaphorical level. I argue that because machine performers are situated, they can also provide intangible layers from the cultural context, and create a special "suspension of disbelief". This develops a more broadly embodied attribution of intention towards any other outside physical objects that act upon the world and affect our behaviour.

But first I will present the definition of embodiment as seen by nouvelle AI scientists, because the underlying principles and methods of constructing embodied agents are important to this thesis. Second, I will show that there are several mini-views of embodiment with various conceptual layers. However, nouvelle AI still tends to target the lower layers of embodiment, whereas I claim (as already indicated) that embodiment spans from the biological to the social. Third, in order to compare embodiments, I will present three of my *machine performer* projects that might actually expand this nouvelle AI notion of embodiment. In these works I have built formulated bodies that attempt to offer drama as a way to understand how a cultural convention can be embodied and enacted upon. These works might share bodily characteristics that are physically designed to "perform" in the nouvelle AI sense, but I used an intangible layer of cultural conventions to place them on stage in a concrete theatrical setting. All these works contain a specific level of historical embodiment:

the *Tiller Girls* (female dancers), the *Blind Robot* (blind character) and *La Cour des Miracles* (characters in pain).

The first work I would like to introduce is the *Tiller Girls*, a dance piece comprising an ensemble of 32 small autonomous robots with a prior history in artificial intelligence. First I will describe how I actually appropriated a robot design (*Stumpy*) from the University of Zurich AI lab and placed it onto the stage. Second, I will show how I inscribed some upper levels of embodiment from the historical context of the Tiller Girls in 1930, and I will ground this enactment in Judith Butler's gender constitution. Third, I will examine the animate-animated equation and scrutinize this equation while the Tiller Girls function and perform on stage. Prompted by Auslander's essay on robot performers, where he employs the Tiller Girls in his central discussion on technical and interpretive skills, I will finally compare the machine performers with the original human performers (Auslander 2006).

Next I will investigate the *Blind Robot* from the perspective of competence and how references to historical embodiment might shift reactions to it. In contrast with *Tiller Girls,* this robot does not have much "innate" physical competence and here I want to focus on social embodiment. The *Blind Robot* was inspired by the Turing test, where the influences of the perceived physical body are removed to give priority to the social body. Actually, this robot's journey was the exact opposite of the *Tiller Girls*': it was moved from the gallery back to the laboratory in order to verify the impact of its fictitious role on audience perceptions. Here I will discuss the results of two levels of quantitative analysis which aimed to verify whether changing the intentions of the robot – in other words its instrumental or affective state – could actually shift perception of its performance. In the final work, *La Cour des Miracles*, I attempted to bind behaviours to a morphology and used morphological computing extensively, particularly a programming technique called "subsumption" developed by Rodney Brooks at MIT Media Lab.

Various aspects of these three works will be compared, including programming techniques, materials and body morphologies adapted for specific dynamics and kinematics that occur when these *machine performers* are re-appropriated into different environments. More specifically I will investigate how their behaviours and emotions can be implemented, even if they do not have a complete computational model. Throughout this analysis I will paraphrase Rodney Brooks' bold paper about intelligence without representation and look into acting or performing without thinking "as" *machine performers*. My main aim is to derive a form of bottom-up "synthetic methodology" for *machine performers* on the stage (Pfeifer, Bongard et al. 2007).

Understanding embodiment has multiple implications for machine performers. One implication is that constructed machines might display a "psycho-physical unity", a quality used in theatrical acting method. Another is that this analysis might give a new point of view about the perception of the machines. Embodiment is also an important frame of reference when attempting to analyse anthropomorphic and zoomorphic reflexes, because we reflect on our own bodily experiences. Finally, it forces us to review the idea of what constitutes "performing" for a machine.

3.2. Embodied artificial intelligence

I am not interested in criticising the whole discipline of AI, but in illustrating the current spirit of this field by concentrating on the meanings of the body and the environment in embodied artificial intelligence. The word "brain" has been purposefully left out in my previous lists of words, because I am seeking for a way to make a machine performer feel animated, which does not necessarily imply that it should feel intelligent. When an audience can only perceive a machine performer's body and its behaviour in an environment like the stage, then the body dominates.

3.2.1. The Embodiment Turn

In the opening chapter of his seminal book *How the body shapes the way we think*, Pfeifer defines the term embodiment in the following way: "an intelligence always requires a body. Or, more precisely, we ascribe intelligence only to agents that are embodied, i.e., real physical systems whose behaviour can be observed as they interact with the environment" (Pfeifer, Bongard et al. 2007, p. 18). Here the far-reaching – and often surprising – implications of embodiment are given a literal meaning: that intelligence actually requires a body. Pfeifer further suggests that the consequences of embodiment are related to our obvious obedience to the laws of physics, as well as to the more complex interactions between physical processes and information processing. In biological agents, embodiment lies between physical actions and neural processing. In a robot, embodiment lies between its actions and its control program, between "body" and "brain". Pfeifer provides various examples where embodiment facilitates the tasks at hand without much brain intervention, for example, the use of deformable materials that help to grasp objects, or the muscle-tendon systems that perform rapid movements (running) and handle all control details. Equally, the morphology and anatomy of the robots built in AI can help sensors to pre-process information. For instance sensors at the fingertips will always face the action of moving forward and hence provide useful, structured information to the brain: for example, when a hand grabs a glass or an object, the anatomical and morphological capacity of the forearm and hand enable it to adapt to different shapes.

Thus the perpetual paradox of GOFAI and nouvelle AI is the highly contested marriage between modeling and simulation. The grasping hand demonstrates that this kind of intelligence resides not only in the brain, where the different memorized forms of drinking glass exist, nor solely on the cognitive level of the object "glass". Grasping intelligence of this kind is distributed and "outsourced" between the brain, the body and the environment. This example is also referenced in the title of an early book by Rodney Brooks: *Intelligence Without Representation: The World is its Best Model* (Brooks 1998, p. 139).

However, as another scientist Ziemke suggests, it is far from clear what kind of body is actually required for embodied cognition (Ziemke 2001). Although he agrees with Pfeifer's view "that intelligence requires a physical body is not at all as accepted as one might think" (p. 1), others like Wilson consider it problematic that there is such an enormous variety of definitions of the term embodiment and of its relation to cognition (Wilson 2002). Perhaps this is why artists are attracted to the term, but I would imagine that the real attraction for creative artists resides in embodiment's empirical formulation, its relation to phenomenology, and how it implies the process of learning by doing. In the course of building a robot within the methodological framework of nouvelle AI, one will aim to produce a behaving robot and not a model of behaviour with these connotations of embodiment. Artists might shy away from complex control systems and look instead into materials and intuitive ways of making things move. In my conversations with Pfeifer we have agreed on many instances where the artistic process of making robotic art is similar to those found in AI laboratories. Some of these same methodologies from Pfeifer's canons have been appropriated to make several of the works included in this thesis.

3.2.2. Pfeifer's Canons in: How the body shapes the way we think

Pfeifer maintains an approach he calls "learning-by-doing": a synthetic methodology that emphasizes the importance of building a physical artefact in order to gain a deeper understanding of a natural system. Within the development of this methodology, he presents a series of design principles for agents. These are*:*

1) *The Three Constituents Principle*: definition of an ecological niche, definition of behaviours and design of the agent. An ecological niche exploits the environment to create a competence (such as water for fish buoyancy and swimming).
2) *The Complete Agent Principle*:
    a. Agents are subject to the laws of physics (energy dissipation, friction, gravity).
    b. They generate sensory stimulation through motion and generally through interaction with the real world.
    c. They affect the environment through behaviour.
    d. They are complex dynamic systems which, when they interact with the environment, have attractor states.
    e. They perform morphological computation.
3) *Cheap Design*: Design must be parsimonious and exploit the physics and constraints of the agent's ecological niche.
4) *Redundancy:* Agent-different subsystems function on the basis of different physical processes, and there is partial overlap of functionality between the different subsystems.
5) *Sensory-motor coordination*: enables an agent to interact efficiently with its environment and to structure its sensory input. Both the agent's morphology and its material properties provide physical constraints to significantly simplify the implementation of control architectures.

6) *Ecological Balance:* The capabilities of an agent's morphology (shape, material properties) and its sensor, motor and neural systems have to be carefully balanced. The capabilities are all ecologically balanced vis-à-vis their ecological niche. Control is not limited to the neural system (or the control program) but rather distributed among all these components.
7) *Parallel, Loosely Coupled Processes*: Intelligence emerges from a large number of parallel processes that are often coordinated through embodiment, in particular via the embodied interaction with the environment.
8) *Value:* Agents are equipped with a value system, which constitutes a basic set of assumptions about what is good for the agent.

3.2.3. Morphological Computing

In traditional robotics, scientists start with particular body morphology and then the robot is animated and controlled to perform certain tasks. In such cases, there are clear separations between the brain (software) and the body (hardware). When the morphology and the materials take over some of the functions normally attributed to the control (brain), Pfeifer calls the phenomenon "morphological computation" (Pfeifer, Bongard et al. 2007). The main argument is that this computation cannot be understood simply by looking at brain mechanisms and their controls; it is the result of a physical interaction of the robot's body in and with the physical world.

The broader field of "natural computing" is also used in this context. It implies borrowing from nature, particularly nature's capacity to repair itself, to evolve and to adapt. In a more specific way, natural computing also means to leave the digital symbolic representations and models found in computer machinery behind. Instead of calculating an equation or a model, turning the digital computer into an analogue computer would then be able to measure the answer. For example, a typical scheme might operate from a question that is later turned into a model, then the model is programmed and calculated, and this results in the answer to the question. A natural computing scheme, however, utilizes an analogy to the question by "building" it, and seeks its answer in terms of observing and measuring this object (Lazere and Shasha 2010, p. 194). The fundamental issue here is that researchers build an object in the world that serves the purpose of measuring or modeling some part of it. For instance, modeling a natural phenomenon could require a differential equation, however, one that measures the phenomenon sees how the differential equation behaves without actually developing the equation.

The most cited and striking examples of morphological computation are found in walking robots. If rigid limbs are replaced and controlled with motors via a system of springs inspired by biological muscle-tendon tandems, control of gait becomes as simple as controlling a periodic movement. Pfeifer claims that with this type of control of the dynamics of locomotion, “[if] properly interpreted, as an exploitation of constraints, “cheap design” can be applied to more complex behaviours” (Iida and Pfeifer 2004, p. 120). For instance, elastic components of legs can provide properties of self-stabilization during locomotion. Furthermore, passive elasticity in the body may do more than alleviate control duties: it can also achieve energy–efficient, rapid locomotion. In sum, exploiting intrinsic natural dynamics (in this case, natural applies not only to the biological but also to the artificial) means simpler control and less neural processing.

This idea of empowering body dynamics emerged from research on passive dynamic walkers, which are purely mechanical devices. These artefacts have demonstrated that given proper environmental conditions (e.g. a slope, gravity, friction) and with very little computation or actuation, biped walking is possible. Since robots of this kind must be designed alongside their environment in order to function, their ecological niche is very narrow. Hence Pfeifer warns that: “the more the specific environmental conditions are exploited – and the passive dynamic walker is an extreme case – the more the agent’s success will be contingent upon them” (Pfeifer and Gómez 2009, p. 80).

When researcher Martijn Wisse designed a bipedal robot called *Denise*, he widened this ecological niche by generating gait impulses from motors, yet he still retained the use of the passive forward swing of the leg (Wisse, Feliksdal et al. 2007). In recent years, when presenting my doctoral research, I have usually referred to two bipedal robots, showing videos of *Denise* moving next to a Honda *Asimo* demonstration. I do not mention anything about the concepts of passive walkers. Because *Asimo* can climb stairs and simultaneously change the speed of its gait, it should be seen as more “competent”. Unanimously, audiences find *Denise* more “natural” and animate while *Asimo* feels more animated. When I reveal to the audience that the blue bucket on top of *Denise* is not a computer with a program (or "brain"), audiences are stunned that such behaviour can be driven by the dynamic inherent in the object alone.

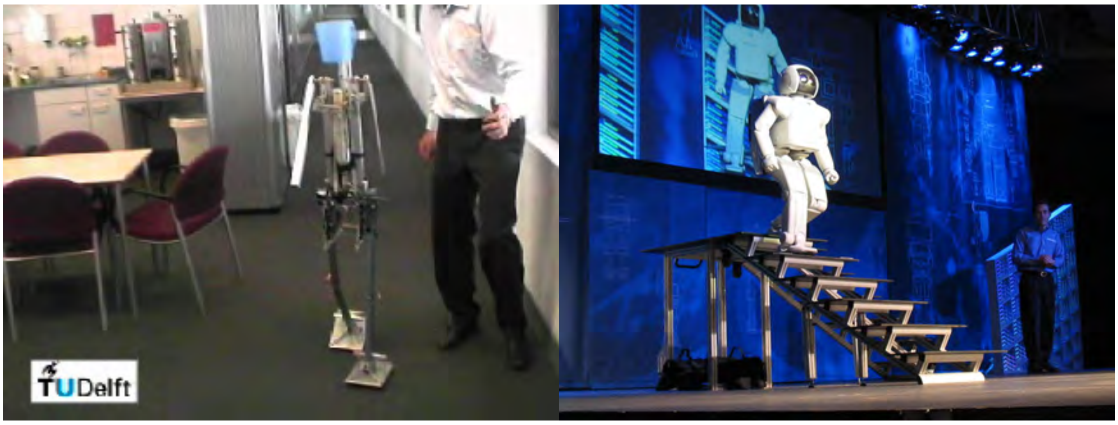

Figure 41 Bipedal robots. *Denise* (2004) by Martijn Wisse and *Asimo* (Honda corporation, 2000)
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This type of morphological computing resonates with Kleist's view of the puppet, where the dynamics rule the behaviour of the object (De Man 1984). When Steve Tellis discusses puppet manipulation, he considers that movements exclusive to their morphology can create the illusion of life. This more easily encourages the audience to accept the living existence of an otherwise inanimate object (Tellis 1992). In relation to dance theatre, when choreographer Susan Leigh Foster presents "the perceived, the ideal and the demonstrative body", she is looking for a meat-and-bones approach to discourses and practices that instruct it (Foster 1986). This "perceived body" is a tangible physical body forming itself via training, attempting to reach the aesthetically ideal body. "The demonstrative body" mediates the acquisition of skills by exemplifying correct or incorrect movements. Therefore, "the perceived body" is natural computing in action. These influences are reflected in my own work, as I shall explain later.

3.2.4. Aligning Control and Body: Performing without Thinking

Another influence is that embodied artificial intelligence reaffirms the role of the body building the construction of complex behaviours. In other words, the design of the body and the process of "animation" have to be integrated (Kaplan and Oudeyer 2008). *Machine performers* that subscribe to the principle of ecological balance can behave because of their intrinsic materials and the complex dynamics of their structure in motion. Such a paradigm is similar to the psychophysical relation found in theatre acting methods, where behaviour and emotions are inherently physically grounded.

Actually, this "outsourcing" of behavioural and emotional models into physical constructions is similar to the creative process of making Kinetic Art. For example, Arthur Ganson's *Thinking Chair* reveals virtually clockwork mechanisms and components to the viewer. Nor does this project need a computer or any interaction with the outside environment: it remains in its own world. Hence, the behaviour of the object can be seen as a deterministic series of actions, much like the old Jacquet-Droz androids of the 16th century. However, there is a delicate tension between the main protagonist (in this case a chair) and its invented world, and hence a slight departure from this determinism. For the audience, the very interaction of the machine performer, when it rubs against an abrasive stone, creates a walking gait that feels "integrated" within its actual body. Regardless of the highly complex Rube Goldberg mechanism attached to the chair, the viewer believes that this chair is indeed strolling round and round like Sisyphus hefting his stone endlessly up a mountain. In this example, the automatic nature of the system is deliberately presented, nonetheless, a perceived agency from the actor is also observed. Even though, this work would fall into "the Uncanny Valley" category for some, its strongly metaphorical image would prevent this for others. Nevertheless, the audience tends to suspend disbelief and engage with the enchantment of this embodied world.

Figure 42. Arthur Ganson's *Thinking Chair* (2007) and Max Dean's *Robotic Chair* (1985-2006)
Permission to reproduce these images has been granted by the authors.

Like Arthur Ganson's chair, the "Limping Machine" of *La Cour des Miracles* expresses an endless attempt to undermine a deliberately installed poor gait. This behaviour can be attributed not only to the unstable equilibrium of the construction, but also to its staging. The introduction of a latent failure in the gait not only creates a poetic moment for the audience, but also gives a supplementary spark of life to the object, proposing it simultaneously as a social robot. Similarly, the "Beggar" that I presented in Chapter 1, had no experience of misery from being poor. Its shape was only a square box (symbol of a chest) that could rock over a hinge (an imploring body language). This researcher focused on a *cheap design* paradigm, in other words he exploited an ecological niche through an *ecological balance* in the object's morphology with accompanying sensing, control and (finally) dramaturgy.

In sum, designing the control structure to be closer to the object's morphology helps the animated body to feel more animate. In *machine performers* the body should be animate instead of animated, intentional instead of functional, phenomenal instead of mechanical, and – as will be further discussed in Chapter 4 of this thesis – it should have a strong as opposed to a weak presence.

3.3. Embodiment

In 2008, philosopher Mark Johnson surprised many people by suggesting that only thirty years ago in mainstream Anglo-American philosophy "people did not have bodies" (Johnson 2008). This attitude was reflected in the cybernetics view where the role of the body was marginalized. Here, signals and models were considered to be an abstract representation that existed in an abstract form independent of their biological carrier. In the last 30 years, Emily Martin notes that the increased interest in the body might also be due to the contemporary historical moment in which "we are undergoing fundamental changes in how our bodies are organized and experienced" (Martin 1992, p. 121). According to Csordas, "the kind of body we have been accustomed in scholarly and popular thought alike, is typically assumed to be affixed, material entity subject to the empirical rules of biological science, existing prior to the mutability and flux of cultural change and diversity and characterized by unchangeable inner necessities" [*sic*] (Csordas 1994) . In his book *Supersizing the Mind*, Andy Clark criticized the cybernetic model because it offered narrow views on our own carrier, the body:

> Fortunately for us, human minds are not old-fashioned CPUs trapped in immutable and increasingly feeble corporeal shells. Instead they are surprisingly plastic minds of profoundly embodied agents: agents whose boundaries […] are forever negotiable and from whom body, sensing, thinking and reasoning are all woven flexibly and repeatably from the accommodating weave of situated, intentional action. (Clark 2008), p. 43)

In other words, the body changed from a simple fact of nature, to one with a history, an experiencing agent, and finally to one that rethinks the distinction between sex and gender. Csordas concluded "The contemporary cultural transformation of the body can be conceived not only in terms of consumer culture and biological essentialism but also in discerning an ambiguity in the boundaries of corporeality itself" (Csordas 1994).

This transition suggests that attitudes towards phenomenology may also have changed since cybernetic days. For example, when Gallagher takes stock of the phenomenological future, he concludes that:

> Phenomenology will continue to be an important player in the ongoing debates about the nature of mind, agency, subjectivity, and intersubjectivity. Embodied and enactive accounts will continue to borrow heavily from established phenomenological concepts and will push forward to new phenomenological insights. (Gallagher 2012, p. 314)

Nonetheless, he warns that:

> phenomenology will continue to struggle to define itself and its methods, incorporating new methods, and being incorporated into different methodological settings, especially in the cognitive sciences. (Gallagher 2012, p. 314)

What this research into embodiment is about is, therefore, mainly finding a rationale that can situate both the emergence of meaning and the grounds for human perception in the movements of *machine performers.*

3.3.1. Csorda's classification

Csordas points out three approaches that are characteristic to the anthropology of the body (Csordas 1994): the analytical body, the topical body and the multiple body.

1. The *analytical body*. This suggests a discrete focus on perception, practice, parts, processes and products. *Perception* here is defined as the cultural use and conditioning of the five senses plus proprioception. *Practice* denotes the classic notion of techniques of the body in motion. *Parts* can regroup as

anatomical constituents and bodily *processes* (such as in breathing). Finally, bodily *products* like blood, sweat and tears can also be analysed.

2. The *topical body* is about the understanding of the body with regard to specific domains of cultural activity. Issues such as body and gender, body and technology and body and trauma are among Csordas' examples.

3. He suggests that the body is more than the sum of its topics, so in his third category, *multiple body*, the number of bodies depends on how many of its aspects one cares to recognize. Accordingly, bodies can be simultaneously analysed as social, physical, individual, or socio-political, or on a curve from the commercialization of the body's needs to the relevant social institutions – in other words as analogues to bodily organs.

With respect to this classification Csordas boldly claims: "Yet of all the formal definitions of the [*sic*] culture that have been proposed by anthropologists, none have taken seriously the idea that culture is grounded in the human body" (p. 6).

3.3.2. Johnson's classification

In another classification by theorist Mark Johnson, embodiment can be analysed from various perspectives. The term spans a wide spectrum of definitions and interpretations of the body, from the functional to the cultural. Johnson posits five interwoven levels of embodiment derived from other theorists that are reported here because I wish to describe their counterparts in robotic projects. Johnson emphasizes that each of the levels he suggests is irreducible and claims that they are an explanation for the bodily dimensions of everything human (Johnson 2008):

1. *The Body as Biological Organism*. The body is a functional biological organism with sensing and motoric systems. It can perceive, sense, move, respond and finally transform the environment (Dewey 1981).

2. *The Ecological Body*. The body does not exist independent of the environment. The organism and the environment are not two separate, nor two fully integrated things (Dewey 1981; Merleau-Ponty 1962). Both organism and

environment bring their own structure and pre-established identity into the interaction that is experience.

3. *The Phenomenological Body*. This is our body as we live and experience it. It involves at least three aspects: body percept, body concept and body affect (Gallagher 1995). The body awareness lies in proprioception (our feeling of our bodily posture and orientation), kinaesthetic sensations of bodily movement, and internal bodily states, the felt sense of ourselves (Damasio 1999).

4. *The Social Body*. The human environment goes beyond the physical or the biological. It is also composed of relations and experiences of the social other. The body does not come fully formed, and it is shaped by social interactions.

5. *The Cultural Body*. Cultural artefacts, practices, institutions, rituals, and modes of interaction that transcend and shape any particular body and any particular bodily action also constitute our bodies.

Because these levels span many theories they seem appropriate to my own work, as I will demonstrate later. But first it may be necessary to take another classification into account.

3.3.3. Ziemke's Classification.

Cognitive Scientist Tom Ziemke also attempted to disentangle the many notions of embodiment (Ziemke 2003). He cited numerous concepts, emerging since the mid 80s from both AI and cognitive science literature covering the embodied mind, embodied AI, embodied intelligence and embodied cognition. Furthermore, Ziemke himself added many other expressions from his own publications about his own concerns, such as mechanistic embodiment, natural embodiment, and situated embodiment. However, although there is now general acceptance that any form of natural or artificial intelligence requires a body (Pfeifer and Scheier 1999), it is far from clear what kind of body is required. While Ziemke aims at redefining the body from the perspective of cognition, many of his examples stem from nouvelle AI, where embodiment is more concrete and immediate. In the following list, Ziemke articulates and compares six different notions of embodiment:

1. *Structural coupling* between agent and environment. This is the broadest notion to qualify a "system" as embodied through its mutual interaction with the environment Here he cites Quick who formally describes this coupling:

    > A system X is embodied in an environment E if perturbatory channels exist between the two. That means, X is embodied in E if for every time t at which both X and E exist, some subset of E's possible states with respect to X have the capacity to perturb X's state, and some subset of X's possible states with respect to E have the capacity to perturb E's state. (Quick, Dautenhahn et al. 1999)

2. *Historical embodiment* as the result of a history of structural coupling. This historical embodiment reflects the course of the construction of the body structurally coupled in the environment. Furthermore, according to Riegler : "A system is embodied if it has gained competence within the environment in which it has developed" (Riegler 2002).

3. *Physical embodiment*. So far, given the first two definitions, systems such as virtual software agents could be defined as embodied. Physical embodiment restricts the notions of embodied systems to the concept of a physical body. An even more restrictive definition of physical embodiment might come from its connection to the environment (perturbatory channels). Brooks refers to physical grounding as interactions not only from physical forces but also from sensors and motors. (Brooks 1990).

    Joining the above notions, *living systems* are a particular instance of physically embodied systems: they are also historically embodied, as many physical systems are not. Although historical embodiment and physical embodiment can both be considered special cases of structural coupling, neither of these two notions includes or excludes the other.

4. *Organismoid embodiment*, i.e. organism-like bodily form (e.g., humanoid robots). Organismoid embodiment links organism-like cognitions to organism-like bodies. Such bodies would have similarities with the sensorimotor capacities of living bodies. This notion of embodiment covers both living organisms and their artificial counterparts. However, an artificial organismoid – as opposed to the living organismoid – is the product of human design and not usually of an historical embodiment.

5. *Organismic embodiment of autopoietic, living systems*. This notion limits the role of embodiment for cognition not merely to physical, organism-like bodies but to living bodies. Rooted in the biology of cognition from Von Uexküll (1928), cognition is what living systems do in interaction with their environment and it depends on an historically created basis for reactions. Machines, at least at that time, would hardly qualify for organismic embodiment due to their lack of growth and fixed structures. In other words, machines act according to plans fixed by their human designer while living organisms are "acting" plans.

6. *Social embodiment*. This addresses the role of embodiment in social interactions rather than questions what kind of body is needed for a specific type of cognition. This discussion is somehow orthogonal to the above notions. For instance, in social interactions we can observe how embodiment effects such as bodily states in others produce bodily mimicry in the self (Barsalou, Niedenthal et al. 2003).

3.3.4. Mechanistic versus phenomenal embodiment.

In a paper about the extreme poles of robotic embodiment, roboticist Noel Sharkey and cognitive scientist Tom Ziemke make a point that bears on the types of embodiment found in theatre performances (Sharkey and Ziemke 2001). They argue that "many of the new roboticists drift between poles of the mechanistic and the phenomenal", and continue:

> In a mechanistic embodiment, cognition is embodied in the control architecture of a sensing an acting machine. […] This is similar to the notion of physicalism in which the physical states of a machine are considered to be its mental state, i.e., there is no subjectivity. (p. 253)

Of course, even the nouvelle AI robot, despite its situatedness and embodiment, does not actually experience the world. Some authors compare this experience of the "real world" with robots whose navigation is electronically controlled by digital tape (i.e. by the designer). They judiciously contrast examples that simulate (or model) embodied cognition via mechanistic embodiment with phenomenal embodiment. In other words, these machines neither have their own sensation nor a body to experience the world directly. The embodiment of a mental or subjective world is called "phenomenal" embodiment. Rooted in Uexküll theoretical biology and *Umwelt* theory, "the organism's components are forged into a coherent unit that acts as a behavioural entity. It is a subject that through functional embedding, forms a 'systematic whole' with its Umwelt." (p. 255). This factor is relevant to the design of new *machine performers* because it is the observer that counts.

Sharkey and Ziemke rightfully state that the meanings of the robot's actions are in the observer's rather than in the robot's world. To illustrate their point they tell the story of Clever Hans (Pfungst 1965), a horse that could perform mental arithmetic, but whose answers were in reality given by means of visual cues from a bystander. As soon as machine performers could be as mesmerizing as Clever Hans to the audience, their stage value was guaranteed. This certainly recalls the mechanical lures I talked about in Chapter 1. While I as a designer understand the behaviours of the *machine performers* that I have created, my own mapping as an observer also counts. My aim here is to argue that this mapping is a kind of communality containing a potential for identification, and that this constitutes a supplementary reason for providing a social and cultural body (as part of my own definition of embodiment) for *the machine performer.*

3.3.5. Embodiment in this thesis

Because of its simplicity, I will mainly utilize Johnson's five levels of embodiment where I will loosely cluster the first three levels, the biological, the ecological and the phenomenal body under the roof of either physical (for the stage discussion) or ecological (for the nouvelle AI discussion) embodiment. Furthermore, I will refer to the upper levels of social and cultural embodiment mainly as "social embodiment". To collate Johnson's levels with the embodiment levels and techniques found in nouvelle AI, I can freely equate the following points:

1. *The Body as Biological Organism*. This is similar to the sensorimotor principle: the mechanical body with its mechatronic systems. There is body schema to enable sensorimotor coupling. I consider that the body of a machine performer functions at this level.

2. *The Ecological Body*. Morphological computing is due here to the close interaction of the robot body with the environment. Machine performers may need a strong ecological niche, possibly emphasized by the turning of a failure into normal machine behaviour.

3. *The Phenomenological Body*. Not many phenomenal bodies are found in nouvelle AI. What might be perceived as a phenomenal body could be due to bias in the observer's perception. For a designer, this is where the body image seems to appear inside the subject inside the foundation of the body schema. This can occur when a machine performer is subjectively coordinated by a human operator who can alter its behaviours or add to its movements by carefully observing its body dynamics.

4. *The Social Body*. A social robotics researcher will create scenarios for his or her agent such as a care-taker, a toy for an infant, a coffee waiter or a receptionist. While social robotics at lower levels of embodiment is often based on bodily gestures, superimposing higher levels of intelligence will tend to implement higher social roles.

5. *The Cultural Body*. Though some consider social robotics to be part of the cultural body, I would consider that robots by artists are the main representatives of this level, since artists are trained in poetic metaphors and abstraction.

Summarizing, the following analysis presents my four *machine performers* in relation to the three different theorists on the theme of embodiment:

Practice	**Embodiment Csordas**	**Embodiment Johnson**	**Embodiment Ziemke**
La Cour des Miracles	Analytical in morphologies, movements and sound. Topical in the production of pain. Multiple in ontological questioning	Biological in sensors and effectors. Ecological in subsumption and morphological computing. Social and cultural in the mise-en-scène of a freak show.	Historical embodiment in morphology and staging. Social embodiment in characters and mise-en-scène.
Blind Robot	Analytical in the physicality of touch. Topical in recognizing the robot as blind.	Phenomenological in the presence of the operator in the loop. Social and cultural in the acceptance of being touched by a blind person.	A blind person as social embodiment. Historical in the competence of the operator. Organismic embodiment in the hidden operator.
Area V5	Topical in the role of the gaze. Multiple as seen from the eyes of the Uncanny Valley.	Biological in the capacity to track and follow people. Ecological in the replication of skulls. Cultural in the icons of death and clinical displays	Physical in its gazing capacities. Social in the interaction with the gaze from the audience.
Tiller Girls	Analytical in dancing. Topical in performing. Multiple if we collate performance theory with machine performers.	Ecological in the morphological computing of balance. Phenomenological as they are triggered live by an operator. Cultural in the icon of the *Tiller Girls*.	Historical embodiment. Social embodiment with the *Tiller Girls* analogy. Historical in the competence of the operator.
Devolution	Analytical in dancing, swarming, walking. Topical if we contextualize these movements within a human performance. Multiple if we compare human and machine performers.	Ecological in the diversity of machine species. Ecological in the use of swarms. Morphological computing with the augmented body of the dancer with mechanical extensions. Cultural in humans and machines sharing the stage.	Social embodiment. *Big Bot* and the *Swarm* are organismoids. Historical embodiment in the prosthesis from the host dancer.

Table 12. Contributing works and their embodiment

In order to explore a deeper analysis of embodiment in relation to AI and also a larger definition of the term, I will use two of my machine performer projects: *The Tiller Girls* and *The Blind Robot*.

3.4. The Tiller Girls

As already described in the Introduction, *The Tiller Girls* is a live robotic performance comprising a group of identical autonomous robots. Originally, the *Tiller Girls* robots were developed by scientist Fumiya Iida and refined by Raja David and Max Lungarella of the Artificial Intelligence Lab, Zurich. Nicknamed *Stumpy*, the resultant robot was constructed to study locomotion and gaits derived from simplified morphologies. These morphologies, in turn, generated a fairly rich set of movements.

When I visited the Zurich AI Lab and went through their online video documentations, I was initially interested in the performative values of this minimalistic and rather mechanomorphic machine. I often build arrays of machines, so an array of Stumpies was an inspiring thought. I must state here that the idea of making an ensemble of dancing robots based on the Stumpies was initiated prior to labelling the group "The Tiller Girls".

While I was searching about machines on stage from the perspective of performance theory, I encounter theatre theorist Phillip Auslander's essay on the performative values of robots (Auslander 2006). Auslander nuanced the performative skills of humans in a range from the technical to the interpretive. He then based his analysis on the Tiller Girls, which he considered mechanistic and solely technical. For me the Stumpies possessed a singular flare for interpretation, and I found myself proceeding in the opposite direction to Auslander: on the basis of a mechanical ensemble, typically considered by humans as purely technical performers, I wanted to demonstrate the interpretive potentials emerging from morphological computing.

Furthermore, by appropriating the performance of the 1930s Tiller Girls, I would not only have a title with multiple associations, but also – by framing the live performance as a dance performance – a background canvas for a theoretical and theatrical analysis of the movement of *machine performers*. In order to make this adaptation, I had to study how humans performed as dancing machines and how machines might be perceived as dancing (beyond operability).

First, therefore, I will analyse the process of *Stumpy*'s development and how it was described and envisioned by its researcher-developers. What are *Stumpy*'s intended behaviours? What is the background of the Tiller Girls, and what do they symbolize in the machine world and in performance theory? Finally, I will examine how I transformed *Stumpy* into my own set of *machine performers.*

By transferring *Stumpy* onto the stage I aimed to bring a new function to the robot. As I claimed in Chapters 1 and 2, an animate machine is perceived differently from an animated machine, so I will show how the function of walking and hopping, from the original *Stumpy* was shifted to dancing. This shift is more than a mere reformulation of functionality; it is about the machine performing to an audience who read its body as a social entity relating to performance history. My main goal was to differentiate between a functional machine seen within the AI context and a performing machine seen on the theatrical stage. The embodiment for AI is limited to the physical context, while in performances, social and cultural levels of embodiment are easier to design. The resultant *machine performers* not only perform movements on the stage, they become gendered because they unfold a direct reference to history.

3.4.1. Stumpy: an Embodied AI Experiment

In early AI publications by its researchers, an anatomical image of *Stumpy*'s morphology is provided thus:

> Its mechanical structure consists of a rigid inverted T-shape mounted on four compliant feet. An upright "T" structure is connected to this by a rotary joint. The horizontal beam of the upright "T" is connected to the vertical beam by a second rotary joint. (Iida, Dravid et al. 2002, p. 2141; Paul, Dravid et al. 2002)

The type of language used here is reminiscent of many current locomotion studies for one, two and four–legged hopping robots. These morphologies, along with proper control, would generate various gaits including stunt-like somersaults performed by one-legged machines. For example, a robot called *Big Dog* became a popular icon[24] for these hopping researches and the flagship demonstration of its stabilization

[24] One Video posted on YouTube, from the manufacturer Boston Dynamics, has more than 13 millions hits.

capabilities, particularly when violently kicked by a researcher onto its side. While *Big Dog* resembles a quadruped and exhibits remarkable locomotion skills, *Stumpy*'s abstract, simplistic shape enables it to achieve a surprising range of gaits with unique characteristics:

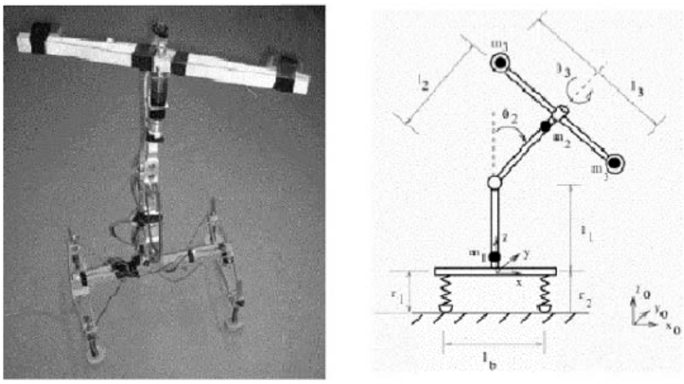

Figure 43. *Stumpy* photograph and schematic- AI Lab 2 (Iida, Dravid et al. 2002, p. 2142)
Permission to reproduce these images has been granted by the authors.

Stumpy achieves locomotion by using the inverted pendulum to induce rhythmic hopping and by using the traverse rotational movements to generate directional control:

> Using this two degrees of freedom mechanical structure, with simple reactive control, the robot is able to perform hopping, walking and running gaits. During walking, it is experimentally shown that the robot can move in a straight line, reverse direction and control its turning radius. The results show that such a simple but versatile robot displays stable locomotion and can be viable for practical applications on uneven terrain. (Iida, Dravid et al. 2002, p. 2141) [*sic*]

The above-mentioned papers on *Stumpy* cover the array of potential values for the respective frequencies of almost any waist and shoulder actuators and their outcome as gaits, including forward and backward walking and turning left or right. It is also observed that these gaits can be modulated by speed and radius respectively. It is fundamental to note that this robot does not actually have legs; or, more specifically, it does not use legs for locomotion. The only body segment that is actuated is the upper body. When static, *Stumpy* has a rather rigid presence: a "T" shape on a stand. One can see it is a legless machine where only the torso and shoulders can move, or as a pendulum (ending with a "T") that bounces around. Zurich AI Lab's video documentations clearly show the reaction of the experimenter, who seems to succumb to a certain charm emanating from the robot (see DVD 4). In 2007, in *How The Body*

Shapes The Way We Think, Pfeifer finally included “dancing” in his description of *Stumpy*’s gaits (Iida, Dravid et al. 2002, p. 2142). Before this, Iida, Dravid and Paul had not mentioned dance in any paper or thesis concerned with *Stumpy*’s locomotion (Pfeifer, Bongard et al. 2007).

The results of embodied AI often start from models of physical agent behaviours without a complete hypothesis. In *Stumpy*, the behavioural model was turned into a physical construct where the apparent jumping actions emerge from the machine’s interaction with the physical world. This is cleverly realized with minimal computational effort and representational models. For example, *Stumpy*can also balance sideways, regaining equilibrium due to its low centre of gravity and soft feet (see gait videos on DVD 4).

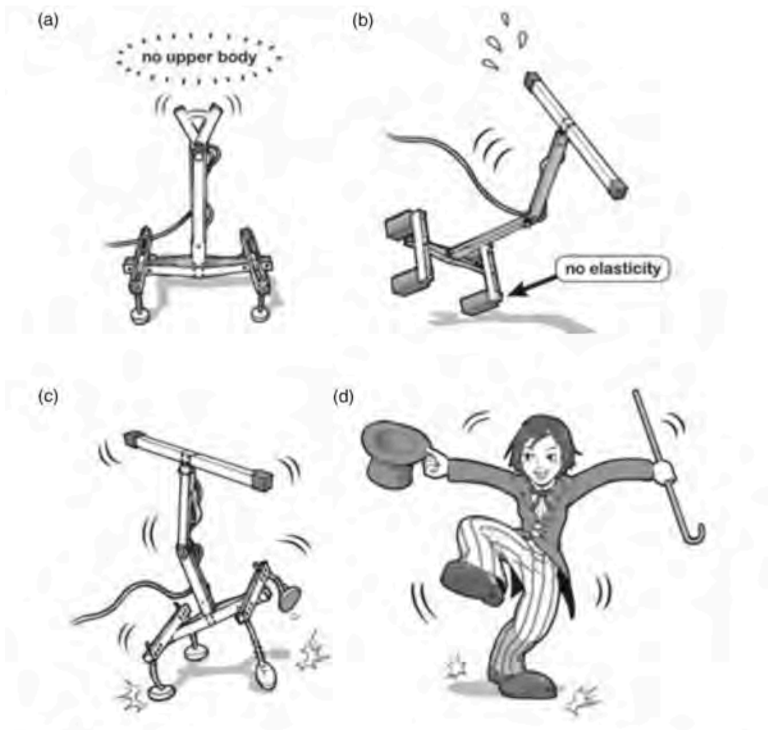

Figure 44. *Stumpy*’s ecological balance demonstrated in comics in Pfeifer’s book (Pfeifer, Bongard et al. 2007, p. 133)
Permission to reproduce this image has been granted by MIT Press.

The idea of empowering body dynamics was also influenced by research on Passive Dynamic Walkers. These constructs have demonstrated that, given proper environmental conditions like a slope or a surface of friction, biped walking is possible without computation or actuators. Since this kind of robot is designed to directly relate to its environment, its ecological niche is very narrow. Because of this interaction between the body and the control dynamics of locomotion, Pfeifer claims that if "properly interpreted, as exploitation of constraints, 'cheap design' can be applied to more complex behaviours" (Pfeifer, Bongard et al. 2007, p. 133). For instance, elastic components for legs can provide properties of self-stabilization during the locomotion process. Moreover, passive elasticity in the body can achieve energy-efficient and rapid locomotion, as well as alleviating control duties. This argument is geared towards Iida and Pfeifer's main conclusion: "the functions of the system are no longer separable from the constraints derived from embodiment, if the behaviour of the robots highly depends on its body dynamics: there is no longer a clear separation of hardware and control" (p. 127). Stability is thus related here to simplicity of control. That *Stumpy* is statically and dynamically stable is exemplified by an exhaustive coverage of the control inputs of the two joints. Part of this dynamic stability is achieved by the springy property of its base. While exhibiting gaits, *Stumpy* does not have sensors to recognize its global states, nor, therefore, does it have any knowledge about the behaviour it is currently involved in, whether walking or hopping. The only feedback is within its motors, enabling it to perform a synchronized oscillation of its two joints.

The following two figures resume various gaits obtained by varying amplitude and angles of *Stumpy*'s joints. In the lateral bounding, the shoulder joint is set at a 30 degree angle. Among various gaits, the first distribution matrix reveals walking patterns, just as the second (the lateral bounding experiment) reveals turning patterns. It is also noteworthy that failure is coterminous here with instability or falling. However, Iida does not consider how the variation within each gait bears on *Stumpy*'s rationale and related argumentation. There is, I would argue, considerable potential in the robot's different walking qualities: higher frequency in a joint, for example, would increase walking energy.

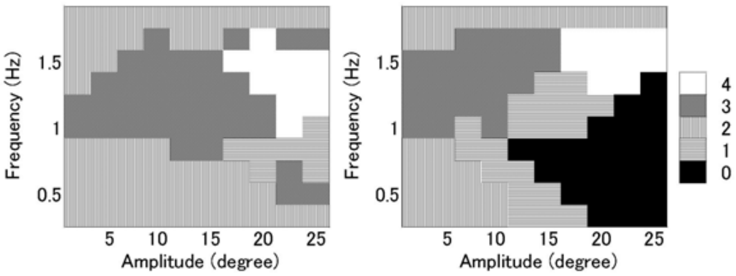

Figure 45. Gait distribution diagram
Shadings indicate different gaits: “4”: Hopping, “3”: Walking, “2”: Shuffling, “1”: Unstable, and “0”: Fall. (Iida and Pfeifer 2004, p. 122)
Permission to reproduce these images has been granted by the author.

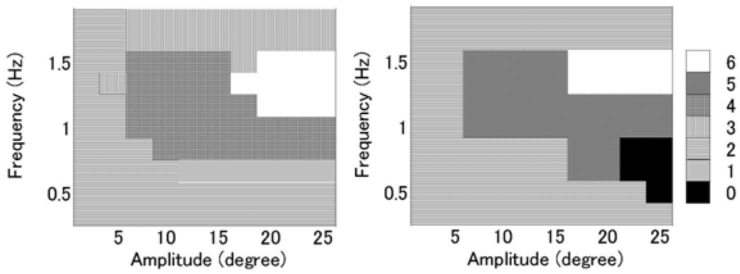

Figure 46. Gait distribution (lateral bounding)
“6”: Hopping to Right, “5”: Hopping and Stay, “4”: Hopping to Left, “3”: Shuffling to Right, “2”: Shuffling and Stay, “1”: Shuffling to Left, and “0”:Fall. (Iida and Pfeifer 2004, p. 122)
Permission to reproduce these images has been granted by the author.

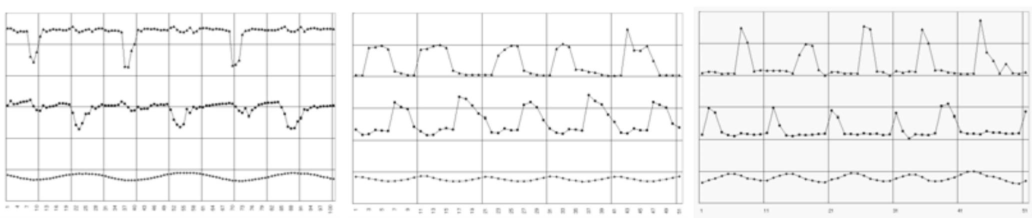

Figure 47. Gait analysis
Three typical gaits, Shuffling (Top),Walking (Middle), and Hopping (Bottom). Each diagram includes time series values of pressure sensors on the right foot (top), the left foot (middle) and the angle between the upper and lower bodies (bottom). (Iida 2005, p. 53)
Permission to reproduce these images has been granted by the author.

3.4.2. From Stumpy to the Tiller Girls

So what might the Tiller Girls dance group represent in the view of humanities scholarship and performance theory? They were famous for their precision kick line dance motion. These precise synchronized steps include rows of dancers with their arms around each other waists to maintain balance, while they kick their legs up high in the air. The Tiller Girls represented uniformed bodies in perfect synchronicity and this would erase the audience perception of the individual; so they could be perceived as a mass-performing object (see Figure 48).

Figure 48. The Tiller Girls chorus line up (TheTillerGirls 1967)
Permission to reproduce this image has been granted by the Tiller family.

Figure 49. The robotic *Tiller Girls* chorus line up (Demers 2010)

Most academic writing about the Tiller Girls refers to this object as a "The Mass Ornament" (Kracauer 1995). As covered in the first chapter, many artistic movements tended to depict the human as machine, an attitude that was influenced by the Industrial Revolution and body culture. Thus Kracauer observed:

> In the domain of body culture, which also covers the illustrated newspapers, tastes have been quietly changing. The process began with the Tiller Girls. These products of American distraction factories are no longer individual girls, but indissoluble girl clusters whose movements are demonstrations of mathematics. As they condense into figures in the revues, performances of the same geometric precision are taking place in what is always the same packed stadium ... One need only glance at the screen to learn that the ornaments are composed of thousands of bodies, sexless bodies in bathing suits. The regularity of their patterns is cheered by the masses, themselves arranged by the stands in tier upon ordered tier. (Kracauer 1995)

Sigfried Kracaeur also saw an analogy between the patterns of a stage performance and the conditions of assembly-line production: "The hands in the factory correspond to the legs of the Tiller Girls" (Kracauer 1995). He read the geometry of human limbs as an allegory, a staging of disenchantment in which mass ornament presents itself as a cult of the physical, mythological but devoid of meaning – an emotion that appealed to me for my own work.

In a dissertation on the Tiller Girls, art historian Kristina Schlosser looks at the live components of this ornament, suggesting that these bodies no longer possess a life substance, but instead serve as cogs in a huge machine:

> The overall emphasis, when a large group of individuals are gathered together, is a patterned, geometric aesthetic in which the particular human units are subsumed and blended together. In agreeance, Kracaeur [*sic*] refers to a loss of "natural substance" creating the effect of removing the individual's personality, humanness, and uniqueness in order for this seamless mass ornament to take priority. This then not only induces the individual into anonymity but also superficially presents the mass ornament as a large force of humanity. (Schlosser 2011,pp. 3-4)

Schlosser continues with her analogy of the machine and replication: "Each Tiller Girl was selected for the chorus line based on similar height, weight, and stature. They performed standardized moves, such as the can-can, choreographed into exact precision with the whole group" (p. 4) – in other words, the Girls were interdependent. She also suggests that: "The machine aesthetic performed by the dancers was meant to influence the physical and emotional responses to technology from anxious, scared, and fearful to more positive amazement and awe of the spectacle of possibility" (p. 16). In support, Kracauer argues that the Tiller Girls represented both, "an ornamentalization of function and a functionalization of ornament".

This effect has influenced a number of other artists: for example, Theo Jansen's leg mechanisms have become an index (and popular icon) of the repetitive line-up of his beach creatures, and he has also suggested that the legs of the Tiller Girls are the abstract designation of their bodies (Nakaoka, Nakazawa et al. 2004; Ikeuchi 2009; Or 2009). Thus, some of the first robots of the 20th century are dancing humanoids. Recently, this interest in moving synchronous robots has been evidenced in the skill demonstrations of androids (Jansen 2008). These small humanoids have become genderless, harmless, wireless desktop-size versions of Olympic competitors who all kick the same way. As Kara Reilly suggests, these "glamorous Ziegfel Follies girls were shaped by that uncanny fetish object, Olympia" (Reilly 2011, p. 144). For while the Tiller Girls may be a sleek machine, they can at the same time become a mechanical monster in the form of an undulating snake. She points out that "auditions for the Tiller Girls did not include any actual dancing but instead consisted of a thorough inspection of candidate's teeth and legs" (p. 145). The cotton factory served as a rehearsal studio, new candidates were placed next to experienced dancers to mimic them, and a head girl acted like a foreman and trained the girls with military marching. According to Reilly, the origins of the Tiller Girls came directly from the cotton mills of England, where workers performed "clog dancing" in syncopathy with their machines to escape the boredom of their repetitive tasks.

3.4.3. My Aims regarding the Tiller Girls as Machine Performers

- To explore if the Tiller Girls could become an embodied version of the Heider & Simmel experiment (in Chapter 4)
- To base the design of robots on a well-known gendered set of movements. How does that change the perception of the audience?
- To investigate the historical embodiment and competence given by association with the original Tiller Girls.
- To see if gender can be constructed through specific corporeal acts (theatrical contexts) and therefore be culturally transformed.
- To explore if dramatizing and reproducing an historical situation can become a mode of embodiment inside a current environment.

- To build bodies (formulation) and offer dramatics as a way to understand how a cultural convention is embodied and enacted by *machine performers.*

- To differentiate between a functional machine seen from an AI context and a performing machine seen from a theatrical perspective.

The biggest question was: Can the Tiller Girls as machine performers elicit behaviours and emotions without a complete computational model?

3.5. *Tiller Girls* production and performance

3.5.1. Adapting Stumpy for The Tiller Girls performance

When robots are built as an AI experiment they are usually able to function for a limited amount of time, and their designers do not have to consider issues from the professional side of performing such as touring and fast deployment. Therefore, I commissioned these designers to construct adapted versions of *Stumpy*, so that it was

1. autonomous, i.e. no umbilical cord to the control computer

2. each could be optimized to run with at least one-hour batteries

3. it could be produced in 12 identical copies

4. they could be wireless networked to control the movement of each robot.

When a new generation of Stumpies was delivered, I made further modifications like:

1. programming an authoring system under Max/Msp and I ruggedizing the Stumpies for the stage (more demanding)

2. fitting protective covers and fixing the batteries

3. fixing flaws in the structural design

4. rebuilding all the electronics so that Stumpies could make demanding movements such as falling on the floor

5. making 20 more copies to accommodate various versions of the show, i.e. 12, 21 or 32 robots – these numbers being derived from the limitations of the wireless network.

3.5.2. Developing the Performance

My intention was never to literally recreate the chorus line and dancing virtuosity of the Tiller Girls. Even if I could have envisioned this scenario, the copies of the Stumpy have enough minute differences that after a few minutes, some Stumpies did not follow the exact same gait. At best, I could evoke or pastiche short moments when the chorus effects of the original Tiller Girls were similar. The first performance with the Stumpies was an impromptu event in my laboratory (see Trailer on DVD Appendix). I then decide to build the performance as a structural unit where the sound, the lighting/visuals and the Tiller Girls' movements were all improvised live.

In their book on Robert Wilson's work, Morey and Pardo describe how the freedom of the automaton can equally be applied to the spirit of the Tiller Girls' performance:

> If the mechanization of the movement – of all movement, whether it be a gesture, a text or a melody – leads to freedom, it is because it opens up a space. While the muscular memory reproduces what has been learned, the rest of the body can attend to the punctuations of that movement; perhaps it can also think about something else. If the automation of the hands, of an arm, or the body that occurs to the vision, is liberating, it is because it activates other channels of the body itself. Other muscles – the muscle of the forearm or the muscle of the spirit – enter into a movement that may not be controlled. (Morey and Pardo 2003, p. 126)

And, commenting on this same repetitive nature of movements found both in Wilson's theatre and manifestly also in machine performances, they continue:

> The repetition leads to that freedom in which repetition itself is annulled. The freedom that is produced by the repetition is converted at the same time into the space in which the repeated gesture is successively modified, at times visually, at others as intensive charge. (…) Repeating, repeating and repeating until the body becomes memory, muscular memory, involuntary memory. In the repetition the body becomes automated, moving by itself. When the body learns in the concentration, it feels, it becomes freer. (Morey and Pardo 2003, p. 126)

When musical score, lighting design and choreographies converge, all the improvisers (in this case *machine performers)* have parcels of phrases for their media that can be assembled and manipulated live. The core of the communication between robots, music and visual environment lies in sharing the control signals sent to the Tiller Girls. In this sense, music and lights follow the Tiller Girls, not the other way round. In this sense the music and visuals are renderings of the Tiller Girls' internal state. This is similar to the non-narrative, abstract aspects of Wilson's theatre:

> There are choreographies in which the bodies do not follow a story that has to be interpreted, but more instead in terms of a conception of time and space that, for Wilson, has its basis in architecture. In these choreographies, too, it is the body in its relationship with itself that is modified, as in Cunningham's compositions, for example, where the dancers do not follow an external score but attend instead to their own internal music, listening to their own bodies. (Morey and Pardo 2003, p. 126)

My performance script consisted of the following tableaux for a duration of around 30 minutes (depicted in Table 13): turning on the machines and making them stand up, a duet followed by group accompaniment, an ensemble, a quartet making a drumming session, a duet that deconstructed the Tiller Girls, a reset where I repositioned all the robots in a line-up as ornamental figures, followed by chaos and extinction. The development of the performance was operated over a series of experimental and informal rehearsals. After lab tests, the second phase of improvisation was during the CyberLab workshop in St. Polten (Austria) and finally two weeks of development and rehearsal in a theatre studio. Each time it was performed, the script and results changed because of improvisation sessions during the set-up of the work. The performance has been presented at ten venues for more than thirty representations and seen by a combined audience of 6000 persons. The following table illustrates some stages of these performances.

	Machine performers - Atmospheric / Kinetic Stage	
I. Enunciating the waist.		First Duet. Second Duet. Ensemble. First duet throws on floor.
II. Establishing the sound rapport.		Ensemble twist sideways.
III. The drumming jam.		Group of four improvising together on drumming sounds.
IV. Deconstructing		The first duet constantly throws itself back on the floor. Another performer joins the duet. Ends when the trio is all entangled or cant move anymore.

V. The Chorus Line.		  	Archetype of the Tiller Girls formation. The geometric patterns break. End when most of the robots have collapsed on the floor.

Table 13. *The Tiller Girls* Performance Tableaux

3.6. Stumpy and the Tiller Girls

In this section, I qualitatively compare, under nine headings, *Stumpy* as seen by nouvelle AI to the *Tiller Girls* as seen in the contexts of art and theatrical performance. Of course I use the word "theatre" liberally: machine performers are certainly not dramatic characters in the sense of a theatre play – they are objects that move on stage.

1. *Body Morphology and Historical Embodiment*. As I have suggested earlier in this chapter, morphological computing is about how the shape and function of the body changes according to its history and environment. When Ziemke discusses how a robot is built, he sees its competence as derived from the history of coupling with the environment. In theatre, the performer is

constructed historically by the given cultural as well as social connotations of the character and by the live audience that perceives and interprets the movements and apparent behaviours. Likewise, with the mechanical performance of the *Tiller Girls* the audience has a phenomenological response to the performance because of the bodily associations they make with their human counterparts. As Judith Butler argues, gender is often an historical situation rather than a natural fact, so the audience assumes the machines are women (more literally girls from the ensemble name). This situation intersects with the physiological and ecological levels of embodiment found in nouvelle AI in such a way as to give the social/cultural embodiment of the machine performer a gender. What makes Butler's remark relevant for our analysis of *Tiller Girls* is that she sees acts that constitute gender as bearing similarities with performative acts. She further suggests that to decipher the starting point of these bodily identifications might be an interesting exercise: "In both contexts, the existence and facticity of the material or natural dimensions of the body are not denied, but reconceived as distinct from the process by which the body comes to bear cultural meanings" (Butler 1988,pp. 519-520). Butler argues that "acts by which gender is constituted bear similarities to performative acts within theatrical contexts", and introduces the notion of ‘‘doing gender, of gender as a performance rather than a fixed, given state" (Butler 2004).

2. In articulating the tableaux of the performance, I build upon Butler's task: "to examine in what ways gender is constructed through specific corporeal acts, and what possibilities exist for the cultural transformation of gender through such acts" (Butler 1988,pp. 519-520). In the *Tiller Girls,* gender is obviously constructed by the connotation of the dance group; and – to extend past gender – the performing acts of the Stumpies define their bodies beyond their clever pendulum as operating in an original ecological niche. Butler writes that "gender is instituted through the stylization of the body and, hence, must be understood as the mundane way in which bodily gestures, movements, and enactments of various kinds constitute the illusion of an abiding gendered self" (p. 519). With *Tiller Girls* this illusion takes a double-vision turn: their gender is obviously not physiological, nor directly linked to actual movements

(however stylized). The interpretation of their enactments, read as female gestures, is tainted by the connotative social values carried by the ensemble's name. There is a mechanical facticity in the Stumpies in that there is no physiological sex and gender is a signification not of that facticity (it can't be) but a signification of a cultural interpretation. In this sense, sexless machines might be better stylized into a third gender – a machine gender – especially if they have non-anthropomorphic bodies. Under the conditioning of the label "Tiller Girls", the audience perception of the historical body supersedes the functional body.

3. *Constructed bodies*. Because the Stumpies are actually balancing metronomes in a mechanical sense, AI researchers aim to discover the influence of dynamics of materials and structures on balancing behaviours. In my theatre performance, I attempt to create a phenomenological body for the audience by expanding simple gaits into dance and by introducing improvised elements (dynamism of the live event). The constructed body of the Stumpy matches the biological and ecological body of Johnson's classification while *Tiller Girls* also constitutes a phenomenological body (audience perception, human operator to orchestrate the gaits) and as well a constructed cultural body.

4. *Gaits*. In nouvelle AI, gaits are intrinsically related to the shape of the object and the main focus is to understand the potentialities of cheap design and of an ecological niche for locomotion. On the stage, gaits are orchestrated to resemble dance movements that also include failures of locomotion (or behaviours). Apparent intentions surface when machine performer movements do not follow Newtonian causality (or folk physics). For instance, after falling down, a Tiller Girls is able to stand up even if its body scheme does not suggest this ability.

5. *Stage and Lab*. In nouvelle AI, robots are not often staged because the aim is to test the functionalities of the embodiment. Experimental scientific protocol usually targets controlling variables, aiming at reproducibility of the experimental conditions. The notion of environment is limited to the physiological level and so it tends to exclude theatricality as a variable. In theatre, the body of the machine performer augments or transforms behaviours

that are derived from similar morphologies (cast of actors). What is interesting for my research is how the liminal situation of the physical body and its representation borders on quite unpredictable situations (Fischer-Lichte 2008).

6. *Autonomy*. One of the aims of nouvelle AI is the construction of autonomous agents capable of operating in their environment. In theatre, as exemplified by *Tiller Girls* and *Devolution*, autonomy is not a central issue but more of a practicality. AI autonomy has the potential to distract from the dramaturgical effect if not properly framed, a factor I will develop later in Chapter 4. Finally, autonomy should not be confused with the animate qualities of machine performers. Autonomy can enhance the animate sensation but it is not essential as soon as the movement feels like it is coming directly from the mechanical object. For example when a leg is not animated to move, but moves by itself.

7. *Environment and co-presence of the audience*. In a lab environment, the audience (observers) deconstruct and analyse the behaviours more than on a stage. When audiences are tasked to assess the functionality of the robots, their emotional reactions are triggered, but they may be pushed aside by the task in hand. (See Stumpy AI Lab movies and staff comments on DVD). In theatre, the audience shares the same time and space as the machine performers, and this creates a co-presence. As explained by Fischer-Lichte:

   > By transforming its participants, performance achieves the re-enchantment of the world. The nature of performance as event – articulated and brought forth in the bodily co-presence of actors and spectators, the performative generation of materiality, and the emergence of meaning – enables such transformation. (Fischer-Lichte 2008, p. 181)

8. *Presence and representation*. In nouvelle AI, the presence of an observer is seen as a value for authenticity, while in theatre, value belongs to how the authoritative controlling mechanisms are represented. This is because

   > In aesthetic theories, presence and representation were long considered oppositional concepts, wherein presence was equated with immediacy and seen as the experience of opulence and completeness, as authenticity. Representation, in turn, belonged to the grand narratives, exerting an authoritative controlling mechanism. (Fischer-Lichte 2008, p. 147)

   While nouvelle AI researchers strive to define how functional robots are grounded in the physical reality connected to the robotic agent, theatre brings together the real and the unreal: fact and fiction. This is what Jean Cocteau called “the realism of the unreal”, a way of blending magical motifs with everyday realism he suggests is something “not be admired, but to be believed”.

9. *Psychophysical and physiological movements*. In nouvelle AI, witnesses of experiments push aside the combination of morphological computing and connotations of movement because they prioritize measurement. After all, they are engineers and they strive to compare the understanding of the robot body-schema with the actual outcome of its behaviours. In *Tiller Girls*, the combination of morphological computing and the associative characteristics of choreography stimulates psycho-physiological interpretations in the audience. As a phenomenological reaction, audiences both identify with the body-schema of the robot and with how they interact (or in this case dance) together.

10. *Cultural and Social*. In the lab, audiences are observers. In the cultural domain, they are the curious witnesses of the construction of fiction. Cultural functions make social relations broader. In AI, researchers strive to make social robots learn to be social over time through exposure to the manmade environment around them. In theatre, learning is already embedded, not only in the experience of the past, but also because illusion is a priority that can be used to create social metaphors. Therefore, while both social robots and *machine performers* are designed to socially engage with people or other robots, nouvelle AI scientists see social interactions as a specific functional attribute, while theatre designers see these interactions with robots as having potential for bodily metaphors and interesting associations.

In conclusion, by taking the same machine, *Stumpy*, and by appropriating it in a different context, broader definitions of embodiment emerge. This is because in theatre, mimicry is based on social, historical and cultural factors and these factors become an integral part of *Stumpy*.

3.7. Performers and *Tiller Girls*

In this section, I move from the comparison of Stumpies vis-à-vis Tiller Girls to the comparison of human performers vis-à-vis machine performers (while focusing on the Stumpies). Since dancers and instrumentalists rely more on patterns and mathematics than a theatre actor (text), the comparison is targeted at the former.

In *Humanoid Boogie*, Auslander tackles the human and mechanical opposition of performing. Yuji Sone sees this as exposing the indeterminacies in the binary thinking found in the traditional performing arts (Sone 2008). Auslander states: "I want to make clear that although I clearly do wish to make a case for seeing machines as performers, I am not proposing that machines can perform in all of the ways that a human being can" (Auslander 2006, p. 90). His main stance is that definitions of performance typically put an emphasis on the agency of an artist who expresses something through interpretation. Hence, Auslander's main argument is that "Although I insist that robots can possess technical performance skills, I will not claim that robots possess interpretive skills" (p.91). Though I agree that machine performers do not perform in all the ways of human beings, I will try to demonstrate that unrecorded and unmodelled machine performers based on morphological computing have some starting ingredients that could lead to interpretive skills in the machine performer.

Auslander develops his argument by confronting performance scenarios whose execution is based on either technical or interpretive skills, and where the latter are regarded as specifically human. Auslander highlights the 'grey' area between these skills with the practised routines of orchestral musicians, and the Tiller Girls' synchronized chorus-line dance, in which human performers are "called upon to exercise their technical skills but not their interpretive skills" (Auslander 2006). In such a context it should be a small step to conclude that a Stumpy-as-Tiller-Girl is solely based on technical skill. After all, its operative element is a simple pendulum. In this context I can regard the interpretive skills of the Tiller Girls in two ways: first through the agency of the chorus and second, through a discussion of apparent agency.

Theatre historian and theorist Tobin Nellhaus disputes Auslander's views on the blurring distinction between human beings and machines in conventional genres that involve repetitive routines. According to Nellhaus, Auslander considers that the performers cede a substantial part of their agency to someone else such as a conductor or choreographer (Auslander 2006; Nellhaus 2010, p. 185). Nellhaus' reading of Auslander is that one either possesses individual agency or cedes agency and becomes machine-like. Introducing the notion of organized group agency[25], Nellhaus disagrees with the view that the demand on a performer's technical skills leads to a loss of agency. He even goes further by stating that the chief alternative to individual agency is to participate in larger forms of agency where the artistry lies in ensemble performance. The concluding section of my *Tiller Girls* performance exemplifies this situation. It operates as a deconstruction of the chorus line, constantly showing the minute (and imperfect) differences in the ensemble that not only act as a counter-intuitive representation of the stereotypical repetitive capabilities of a machine but lead to structured chaotic "improvisation" of the ensemble. The programmed motions of this section of *Tiller Girls* are based on a set of individually fixed movement phrases that can be modulated live (via speed and energy for instance). Delivered as an ensemble, night after night, the patterns, clusters, and falls are always different and always tainted by various apparent individual machine performer's interpretations (for similar movements, some machines end up on their flanks, some standing in a duet, some in the audience). This situation could not be claimed as the result of pure randomness; it is the result of an organized improvisation. I will cover other instances of this corporate agency in Chapter 4. I will present an aesthetic reading of this corporate agency that shows how a flock of machine performers can produce atmosphere.

At the beginning of his paper Auslander outlines when a machine can perform or not. Based on Tellis (Tellis 1992; Nellhaus 2010, p. 185), he discards the automaton as a simple animated kinetic sculpture, nuancing this notion on the basis of playback devices[26] such as a programmed automaton, and he sees some mechanical works as technologies of production not reproduction (Tellis 1992; Auslander 2006). Auslander would consider machines as part of performance when they go beyond the re-creation of a prior performance. Auslander then brings examples of robots and activities that potentially demonstrate a certain sense of agency but not interpretation. Starting from

[25] Nellhaus calls this "corporate agency".
[26] Auslander's body of work deconstructs the concept of "live perfomance".

performance theorist Michael Kirby's concept of nonmatrixed[27] performing , he demonstrates that some stage actions are based solely on execution (Auslander 2006; Kirby 2011). Auslander then brings a solid example with *The Table* by Max Dean (1984-2001). *The Table* is a machine shaped like a table that chooses to follow certain persons of the audience in the room within which it is set. Auslander rightly claims that this machine goes beyond the playback device to the level of performance, but he still situates the decision making of *The Table* as a technical performance, like the nonmatrixed performing of Kirby. He uses this example to contrast apparent agency with real agency, while showing that in such cases there is no difference in overall artistic intention whether a human or robot performs the task.

Here I would simply follow up on the discussion about the mechanistic and phenomenal embodiments found in robotics (see Section 3.3.4). Walter's *Tortoises* were not hungry, they simply executed a nonmatrixed set of rules. However, machines that begin to make incursions into the phenomenal body, such as those guided by morphological computing, depart from nonmatrixed performance. It is difficult to root interpretive skills in the physiological/ecological embodiment unless we consider machine interpretation as the unpredictable movements issued from the coupling of the robot and its environment. The interpretive capacities of the Tiller Girls are based on two elements: their enactments through morphological computing and my operations and modulations of their movement phrases. Even though *Stumpy*'s body does not sense itself, its construction does: this is morphological computing. It has a tendency to stay upright and self-stabilize. Even if such construction sounds like a pure mechanical production of movement, the object-in-the-world really departs from the level of simple "closed" automaton. This specific machine performer does not fully claim equivalence to human interpretation. However, the staging brings intentionality (this will be demonstrated in Chapter 4), just as the live operator injects interpretive skills into the Tiller Girls. As seen from the audience – and as with puppets – the manipulator is part of the image, but the puppet is the location of the interpretation.

[27] These, like happenings, are task-based, non-representational events, where a performer does not feign or present any role, but is simply being himself or herself, carrying out tasks.

Fischer-Lichte attributes an aura to objects on stage but denies them the quality of presence. She proposes a range of presence: weak, strong and radical. The weak refers to the mere presence of the body onstage, the strong refers to the performative value of the body and the radical intertwines the semiotic and phenomenal body Fischer-Lichte 2012). When she applies her scale to objects, she argues:

> While aura is frequently applied to objects, only the first two concepts of presence allow for such an application. Objects can command space and attention and qualify for the strong concept of presence as long as these qualities are detached from the embodiment processes. The radical concept, however, cannot be attributed to objects. Objects are frequently perceived as present, especially in theatre performances and performance events. The radical concept of presence requires the idea of an embodied mind at its centre and therefore has to be limited to human beings. (Fischer-Lichte 2008, p. 100; Fischer-Lichte 2012)

And she continues that “presence brings forth humans as that which they always already are: embodied minds. Ecstasy, in turn, makes things appear as what they already are but which usually remains unnoticed in everyday life because of their instrumentalization.”

Giving an historical body to the machine performer can also alleviate this very instrumentalization. Such action makes the machine performer depart from the simple object status of a prop. I would, then, attribute radical presence to machine performers, seeing them as an embodied mind, the result of a staged construction given to the machine performer. In this chapter’s section on the *Blind Robot*, I will show how I give this machine performer a mind (intentionality) and an expertise (touch) by the mere ascription of character to a pair of embodied arms. This aura will be discussed more extensively in Chapter 4.

Fischer-Lichte’s presence scale also tries to nuance the grey area between *having* a body and *being* a body. Here I would return to the previous chapters and refer to the animate and animated qualities of machine performers. The animated body is simply an articulated structure, while the animate body has some perceptible essence of inner motivation. I would claim that morphological computing helps the machine performer to “*be* a body” since enactments are not issued by a model (*having* a body) but emerge from the ongoing actualisation of the body in the environment (*being* a body).

Machine Performers: *Stumpies as Tiller Girls*	*Human Performers:* *Dancers and Instrumentalists.*
Movements are the result of an effector articulating a given body schema, potentially sensing its environment.	Movements are both the results of body schema, body image and cultural and historical bodies.
Inanimate object becoming animate. Machine performers can become more than just “things” by borrowing techniques of presencing.	Performers have the tacit capacity of presencing.
Randomness from natural computing, incorporating failures and other “unaccounted for” parameters.	Performers’ historical bodies can contribute to randomness of movements via improvisation and interpretation.
Machine performing – aliveness.	Live Performance – liveness.
Technical Skills from mechanical construction and design.	Technical skills from training.
Performing from its own construction, its own body. Potentially enhanced by an operator (similar to a puppeteer). Stumpy is similar to a puppet, they are linked by virtual strings to the computer/operator/puppeteer that makes them move.	Interpretive skills.
Even with carbon copies, a machine performer body becomes unique through minute variations in its construction that impact on its movement. Individualities are also created by contrasting one robot to a mass of robots.	Biological individualities. Historical individualities.
Initially mechanomorphic but becomes anthropomorphic through staging.	Initially anthropomorphic but becomes mechanomorphic by repetitive movements.
Constructed, synthetized, and historical embodiment vested by mise-en-scene.	Biological body grows and is constantly shaping and reshaping itself. Historical body is developed only through time and experience.
Limited to a “niche” but yet its impact can be optimized. For instance, *Stumpy* as a dancer of “Mass Ornament”; the singular body movements of water puppets.	Multi-tasking.
Multi-stability in the order of presence and representation. Fischer-Lichte (see Chapter 2.) Stumpies as Tiller Girls humanize the mechanical performers. Mechanomorphic turns into anthropomorphic.	Multi-stability in the order of presence and representation. Fischer-Lichte (see Chapter 2.) Tiller Girls turns human performers into mechanical performers. Anthropomorphic turns into mechanomorphic.
Transfer from functioning to performing opens audience interpretation of stage acts.	Expression and development of vocabularies of movements. Cultural codes of dance.

Table 14. Comparison of Machine Performers and Human Performers

3.8. Contributing work: La Cour des Miracles

In another work, *La Cour des Miracles*, I also borrowed, two elements from nouvelle AI: morphological computing and Rodney Brook's subsumption control architecture. Following the ecological balance, my design and programming aim was to align the body and its animation as far as possible. Through their intuitive way of modelling behaviours, both methods help to generate behaviours that are less scripted and that appear more rooted in what "happens now" to the robot. My goal was to achieve life-like behaviours out of minimalist constructions, an amalgam of basic tasks issued from empirical models (see the images of *La Cour des Miracles* in Chapter 1).

The main idea behind subsumption is to loosely couple tasks together without the need for a centralized controller or a global representation of the exterior world. A complex task is broken down into many simpler tasks that are organized into layers. The layers form a hierarchical structure where higher-level tasks can subsume other lower-level tasks, taking over their control. Layers correspond to particular goals of the agent, where higher layers are increasingly abstract. The lowest layers can work like fast-adapting mechanisms such as reflexes, while the higher layers work to achieve overall behaviour. In the absence of this control, lower levels carry out their actions without being planned from the layers above them. The key is to consider these layers as semi-autonomous, with their own view of the world, and only adjudicate conflicts when layers interfere with each other. In other words, this architecture helps to coordinate disparate functional components without requiring a globally unified scheme. Most examples of subsumption deal with small autonomous robots navigating in the environment. In this case, a low level task can become an obstacle avoidance gambit that feeds information to upper levels, such as going forward or urgently looking for a power source in order to recharge its own batteries. This subsumption architecture typically uses what is called in AI "a bottom-up approach" to information flow.

Though Rod Brooks did achieve robust and simple control of small autonomous robots with this architecture, the wider AI community claimed that results were mostly at the insectile level. Designing high levels of competence is difficult, as these would depend on the design and implementation of lower levels of competence, and on how the subsumption network and adjudication decisions were made. Thus the architecture seems to work better when it deals with reactions to its environment than when it has a task like reasoning. However, Brooks pointed out that the socially competent robot *Cog* seemed to his audiences more than competent. *Cog* has various eye movements that mimic saccade – the way in which muscles use the visual field to fixate an object – all organized by subsumption architecture. So *Cog* appeared to be taking turns when interacting with a human, but actually these movements were a simple result of organized "reflexes" that obscured the causation to bystanders, who were unaware of the control in action (Brooks 2002, p. 91).

For my *machine performers* in *La Cour des Miracles,* I borrowed the ideas of subsumption from Brooks' programming in order to bring about an interaction with visitors. I found this programming architecture interesting, because it not only subsumed control of the motors but presented me with a loosely coupled authoring system where I could throw in various behaviours that were then assembled and synthesized according to the flow of sensor information and the compound state of the machine. By compound I mean that the condition of the machine performers is represented not by a single state but by an ensemble of states. What I obtained from this was, therefore, not an actual model of behaviours but the unfolding of events within the programmed architecture that showed me how the object behaved. For instance, I could implement a set of primitive (reflex) actions, but the interconnection scheme often caused a more complex (compound) behaviour to emerge. Thus in a convulsive machine, the movements will not follow a single "choreography" but are the cumulatively subsumed result of several smaller primitive choreographies happening at the same time.

In *La Cour des Miracles* the levels of "sensor excitation" can be layered to control the layers in the machines. The robot is retrofitted with four motion detectors covering its perimeter, each of them facing outward and aligned with its corresponding limb. If the machine does not sense any presence in its vicinity, it simply performs a normal routine and waits for a change in the environment. When a sensor detects a movement, the corresponding limb reacts as if in reflex to the intrusion. When two sensors detect the presence of onlookers, the machine develops a more frantic behaviour (defensive parade per se) aimed in the direction of these sensors. When three sensors are active, it means that visitors are close to the machine's upper and lower parts, and this triggers to-and-fro motions of the whole machine. When all sensors are active, it means that people are surrounding the robot and the machine either reaches a very high level of excitation or shuts down and plays dead. The sensing information also incorporates attributes such as the duration of the presence detected. For instance, this duration can modulate a reflex-based behaviour, making a contraction larger or a spasm faster.

The subsumption approach inside the control scheme then decides whether the motion of a limb is the result of a reflex process or from a higher layer (full excitation). This decision either suppresses the reflex and lets the excitation prevail, or lets the reflex "emerge" and overrides the excitation, or randomly selects one of the two, or merges the motion in some form of chaos. The following is my max MSP software diagram for these reactions:

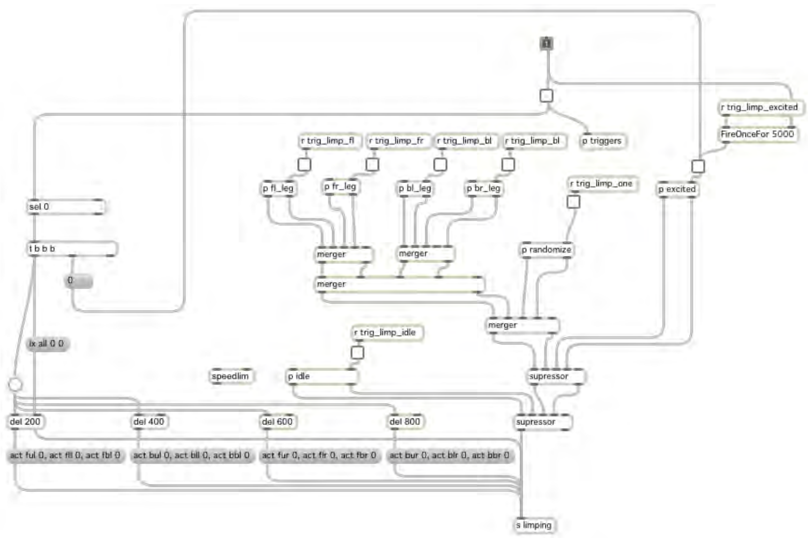

Figure 50. Subsumption for *La Cour des Miracles*

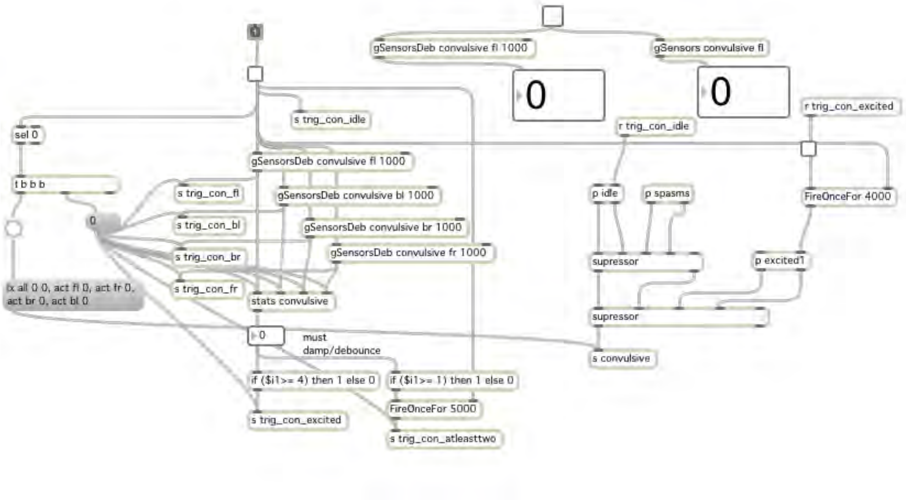

Figure 51. Subsumption for *La Cour des Miracles*

In Figure 51, I have programmed a subsumption scheme with the graphic object-oriented system Max/Msp/Jitter. In this data flow, there are boxes labelled merger and suppressor that correspond to the subsumption functionality. One can read the flow of actions of the machine: two simpler behaviours (idle, spasms) are potentially suppressed by a higher behaviour (excited) to form the resultant behaviour while the sensor data is fed everywhere in the data flow network. Manifestly, this scheme is tailor-made for this machine and matches its morphology and the niche of the robots (on the floor, balance is always assumed). Although it is an incomplete map, the model of the machine in *La Cour des Miracles* creates a network of potential actions, as actions are assembled in real time.

In Chapter 1 I wrote about the lures of automation and also the credible embodiment of pain found in *La Cour des Miracles*. In the following quote, Sharkey and Ziemke summarize how the perception of such staged characters (*machine performers*) might work:

> Behavior-based robots are all designed by humans so that their movement in interaction with 'cues' in the environment, e.g. lights of a particular intensity, looks, to human observers, like the behaviour of an organism. Even if artificial neural adaptation or evolutionary methods are used to develop the physical structure and control systems of a robot, the goals or purpose of the system are designed by the researcher to make the work comprehensible to other human observers. These goals implicitly direct the themes of research and give the devices their credibility as autonomous agents. Essentially the experimenter (who is also an observer) can search through 'cue' space to find appropriate cues that lead to the satisfaction of their goals. These goals are not the robot's but merely an instantiation of the experimenter /

> observer's goals. Thus the robot's interactions with the world carry meaning only for the observer. (Sharkey and Ziemke 2001, p. 260)(Sharkey and Ziemke 2001)

In the end, the perception of pain may be real, and this was in fact suggested through the historical embodiment of these machines. What is assumed is the internal state of the machines, the causal sensorimotor effect of the pretence of pain. What makes this machine performer animate is its morphological computing, which creates a mechanical embodiment of pain, an analogue state that I cannot even fully demarcate, even though I am the maker of this object.

3.9. Contributing work: *The Blind Robot*

Blind Robot was built as an experimental instrument to assess the impact of giving a character a morphological structure. Since there were antecedents in social robotics surrounding the subjective response to robots that could initiate touch, an experiment along these lines would, I conjectured, give me grounds for comparison. Moreover, the scientific results I was inspired by came from Georgia Tech's team, who were interested is creating a relationship between a nurse (robot) and a patient (human), with touch used instrumentally rather than affectively (Chen, King et al. 2011). They suggested that discomfort is based on the potential misinterpretation of a nurse's intention during the touching of a patient. Consisting of a blend of instrumental software that could affect the type of its touch, the *Blind Robot* was built to discover the participant's body. It was a psychological experiment in which participants were presented with two body roles : first with the robot as a device that examines the body to gather medical data and secondly, as a specifically blind robot that needs to touch in order to discover. The results show that the blind character's intentionality was clearly grasped by the visitor, and consequently people became less afraid of being touched by the character than they would have been by the robot as mere instrument.

3.9.1. The Blind Robot as a Turing Test

This preference system was inspired by the Turing Test, which – like Claude Draude, professor of socio-technical system design and gender – I also wanted to reconsider. For Draude, Turing's experimental setting was of far-reaching importance for the relationship between machine and human. Looking more closely at an earlier formulation of the tests she noted that

> The Turing test, proposed in 1950, challenges the ability of a computer to engage in human-like conversation. While various critics analyse the notion of machine and intelligence Turing had developed, others have stated that the gender relevance of this ''founding narrative of artificial intelligence and cybernetics'' at most times gets neglected when the test is mentioned today. (Draude 2011, p. 322)

When Turing developed this scenario, he invented a gender imitation game where different roles were attributed to each gender. The imitation game was

> played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game, he says either 'X is A and Y is B' or 'X is B and Y is A'. (Draude 2011, p. 322)

According to Draude, in the process of splitting (or hiding) the human body and the sign in his experiment, Turing typecasts the woman role and by doing so, his test produces a gender-based performance asking the man or the woman to assume the gender (Butler 2004). Turing suggests that a man may transgress his gender while a woman can be of assistance to the operator. However, for his third test, Turing eliminated any reference to the human body, voice or even handwriting, for the interrogation is actually replaced by a typewriter. This typewritten language is then considered free of connotations that the embodied human actually induces. A correct answer to the test reunites the enacted and the represented body. A mistake demonstrates that the enactment and the representation is no longer an inevitable certainty but a contingent production of identity. This gender/machine performance had a major impact on Draude because, "It is this decoupling of the sign and the human body which makes it possible to attribute a rather radical, subversive potential to the 1950s Turing test" (Draude 2011, p. 322).

In my experiment, the Blind Robot becomes an embodied typewriter, a manifestation of the suggested character. The Blind Robot is rendered genderless in the process of substitution of the characters but in turn, the gender issue inevitably reappears in each visitor's experience. Turing's interrogator becomes the visitor but he/she is not directly asked to reunite the touch and the motions of the robot with its role. The enactment and the representation of the Blind Robot are, as far as possible, invariants in my test. But the suggested role becomes the experimental "variable".

What I intended to show is that in the process Turing actually decoupled an anthropomorphic machine from its behaviour. Here the embodiment is mainly social and does not really connect to the physicality of the robot.

3.9.2. Building the experiment by contrasting with a social robotics experiment

Georgia Tech's team staged an experimental scenario where a robot touches a participant (Chen, King et al. 2011). They proposed two sentences that are spoken by the robot, to the participants in the course of the experiment. The instrumental sentence is: "I am going to rub your arm. I am going to clean you. The doctor will be with you shortly." and the affective sentence is "everything will be all right, you are doing well. The doctor will be with you shortly" (p. 260).

Their hypothesis was that "Participants will find robot-initiated touch more favourable when it is perceived to be instrumental versus affective" (p. 259). This hypothesis is aligned to clinical hospital research where: "Touches from nurses on the face, leg, and shoulders were perceived as uncomfortable by patients. Only instrumental touches on the shoulder and arm by a nurse were viewed as comfortable (p. 258). As the robot touch is invariant in their experiment, their experimental results are that "Significant variation in responses resulted not from differences in the physical interaction, but from the participants' perception of the robot's intent" (p. 262). The team then concludes: "We believe an important general result from our study is that perceived intent can significantly influence a person's subjective response to robot-initiated touch" (p. 264). Although I consider that the patient-nurse situation calls for professionalism and a fair amount of instrumental touch, the empirical results from interacting with *Blind Robot* seemed to go in the other direction. Equally, my original hypothesis was that this agent might be more accepted because it is perceived as blind and that the empathic touch of a blind robot could be more acceptable than a cold neutral instrument. Given a perceived intent that is rooted in an empathic character, the touch of a robot seems to be more accepted from the blind character than from their device character, i.e. from the affective (empathic) touch rather than the instrumental touch. Therefore, instead of eradicating the intent, I decided to investigate what happens if the situation is constructed to cause another direction.

In order to compare my results with those of the Georgia Tech team, I decided to administer a survey that would include questions from their own experiment. From their questionnaires I included the standard Self-Assessment Manikin (SAM) and the Positive and Negative Affect Schedule (PANAS), both made to assess the participant's state of reaction. I also included a subset of the questions that are targeted in their hypothesis. And I included a method called a Godspeed questionnaire for the sake of comparison with other experiments in the social robotics field.[28] This questionnaire dealt with anthropomorphism and also with perceived competence and safety. The full questionnaire can be found in the Appendix of this dissertation.

3.9.3. Procedure and data gathering

The laboratory setup is presented in Figure 52 and Figure 53. The ambience during the test was not intended to be a clinical trial; instead it uses an artistic gallery setting. The Blind Robot protrudes from a wall that separates the control equipment and the human-robot area. Away from this area, there is a table where the participants sit to fill in the survey after their experiences. At the end of the wall stands another control table where video and motion capture equipment are located. In each session I gathered a survey, a video recording (side view) and a motion capture of the movements of the arms, hands and one finger. This motion capture also grabbed a video from the frontal position. The motion capture data was collected to further analyse the movements of the robot to detect potential discrepancies or differences between each session. Although this data will be analysed outside the framework of this thesis, some interesting results are worth reporting.

Figure 52. The *Blind Robot* experimental setup (atmosphere)

[28] See my remarks about this questionnaire with *Area V5* in Chapter 2.

Figure 53. *The Blind Robot* - Experimental setup (work lights)

The participants were all students and faculty from the School of Art, Design and Media at the Nanyang Technological University in Singapore where I teach. The experiment accepted only one visitor at a time to limit the influence of bystanders. The participants were invited to sit on a chair in the front of the blind robot while they were briefed about the upcoming interaction. After asking about their conditions, such as vision impairment or if they had any prior knowledge of the experiment, the students were invited to approach the robot, where they could read one of the two statements that describe it as either a device or a character. In order not to influence the participant, the name of the work – *Blind Robot* – was never mentioned. When the participants filled out the survey, a copy of the statement was left on the desk. When they completed the survey, they were asked not to communicate any of their impressions to fellow participants in order to limit prior exposure that might bias the data. The two texts were as follows:

- "This is the Blind Robot. This robot has no eyes and in order to 'see' you, it creates a mental representation of what its fingertips have seen. The robot will need to explore you, to touch you, your face, your upper body and sometimes even your legs."

- "This robot is being studied as an instrument to measure biometrical information of the body. Doctors and psychologist will be able to interpret various kinds of reactions from your bodies towards their diagnoses. The robot will now sense you and touch your face, your upper body, and perhaps even your legs.”

3.9.4. *Analysis and discussion*

Since the period of tests was a whole week and the concentration required by the operator to manipulate the robot is high, I had to factor in changes of operators during the experiment, but the response of operator 2 was quite different from that of operator 1. The valence in the self-assessment questionnaire had a mean of 5.85 for operator 1 as opposed to 7.08 for operator 2, and the two way ANOVA reported a significance of $F(1.72)=13.32$, $p<0.0005$. The positive valence was more pronounced for operator 2 if it was the blind character with significance of $F(1.72)=13.93$, $p<0.0004$. I will therefore report values independently for each operator.

In the PANAS questions, I looked more closely at the emotional states related to the situation such as being afraid or distressed, both indications of a negative assessment of the intention of the robot. I soon observed that this data gave conflicting results between the operators. It seemed that the quality of manipulation shifted the whole perception of the proposed characters. The emotions that indicate the preferential shift from the instrument to the blind robot were: distressed, enthusiastic, alert, inspired, attentive, jittery and afraid. I performed a two way ANOVA on some of these categories and for both distressed and afraid, the exposed character was almost significant with both operators ($p=0.065$ and $p=0.09$ respectively). When considering only operator two in a post hoc tests, people were much more distressed and afraid of the instrument, with $p=0.055$ and $p=0.06$ as significant levels.

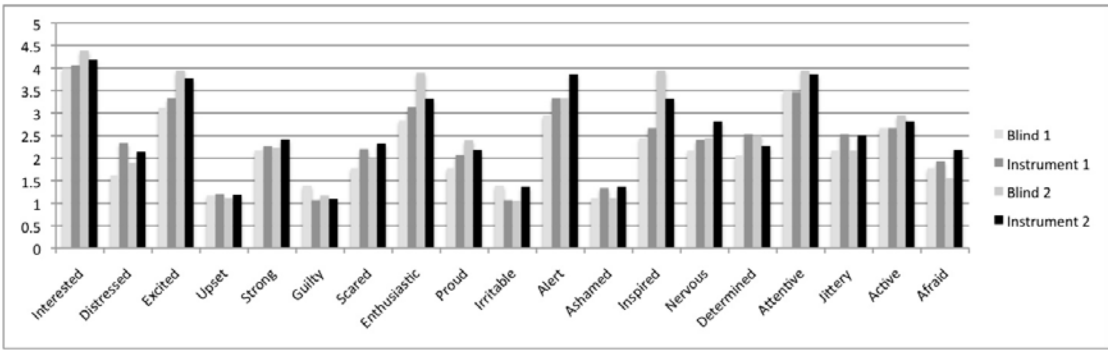

Figure 54. PANAS results

Figure 4 reports the participants' experience. When asked if they were confused about the touch, the instrument made them more confused than the blind robot with significant levels obtained in the ANOVA of F(1,72)=3.62, p=0.06. Again for operator two, the significance increased with p=0.04.

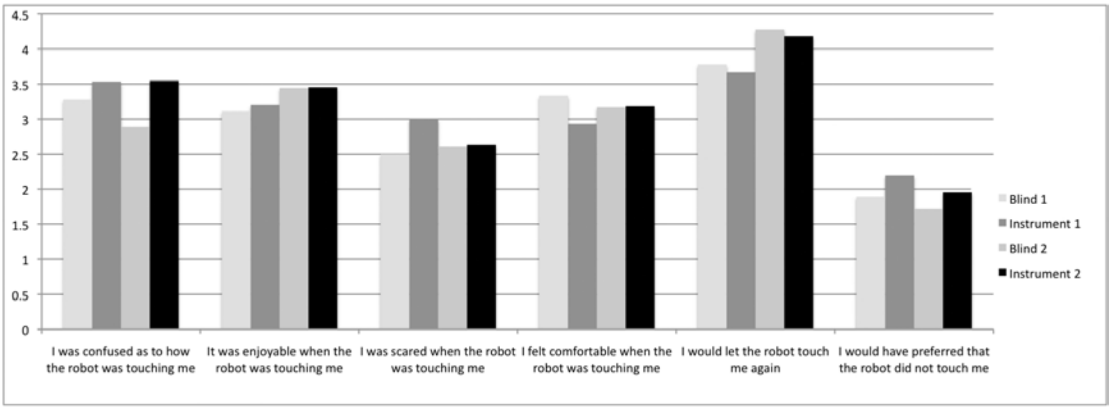

Figure 55. Participant experience results

The results show that the intention behind the robot's touch seemed to be better understood than that from the instrument. This does not mean that it was more enjoyable but that it was more comfortable. Our social rules and codes dictate to us that a touch from a blind person will be positive and needed for his/her perception. In this experiment, a blind touch has more potential to be affective than the instrumental touch of the device. Therefore, I do claim that I had opposite results from those of the Georgia Tech group, as I had indications that people preferred the touch that was more personal (affective). In this case, the intention was socially accepted for a blind person touching a stranger. The problem might not lie in the affective or instrumental touch but more in the elucidation of the intention behind the touch. Finally, an empathic character did manage to create the impression of a positive intention in the vulnerable and intimate touch of a person's face with a robot.

3.10. Conclusion

In embodied AI, the notion of environment is limited to the physiological level. It excludes theatricality as a variable because fiction is not considered a scientific method. By taking an AI robot away from its lab and using it in a different context, I illustrated that a broader definition of embodiment enables a richer palette of perceived behaviours. I demonstrated that methodologies from morphological computing could be transported and applied to *machine performers.* This creates a tighter coupling of the animation process to the given morphology of the robot. These techniques can enhance the stage presence of the *machine performers*, causing more fully embodied behaviours to occur with apparent energy and inner motivation. This presence makes the audience see the machine performers' actions as agentic as opposed to strictly functional. Thus, on a performative level, I claim that the audience identifies more with an agentic object than a functional object. Morphological computing also helps a machine performer to have both performative and interpretive skills. Moreover, morphological computing enables the machine performer to reach the radical concept of presence put forward by Fischer-Lichte. With *Tiller Girls*, I challenged her claim that the radical concept of "presence" can only be applied to human performers and not to objects.

As opposed to science, failures and mistakes can be fully exploited by designers of machine performers. From the AI standpoint, a Stumpy with an ill-formed gait is seen as a negative result, but in *Tiller Girls* such a gait can create a sense of suspense (like falling) or a sense of spontaneity (like jumping for no reason). In nouvelle AI, mimicry in the physical embodiment is one the main focuses for researchers. By adding new variables, such as the vocabulary of the mise-en-scene, *Tiller Girls* is designed to shift locomotion gaits into dance vocabulary. While the physical embodiment of the machine performer is essential, the social embodiment of the robot is the main focus to create perceptible and empathic behaviours for *machine performers.*

Behaviours that are attributed to agents do not necessarily embody subjectivity in the final perceived intention. Walter's tortoises are regarded as hungry and the machine performers in *La Cour des Miracles* as sadly suffering. Even the largest geometric figures of Heider and Simmel's animation are regarded as aggressive characters.

The designer of a *machine performer* aims to create a competent body that will radiate with intention. Whether simulated, modelled or computed naturally, the fact of its being given a set of perceived behaviours means that the machine performer has to first align its animation with its body in order to become a credible agent. Its animation (behaviours) has then also to be aligned with its given social embodiment. These behaviours will make the fictitious historical embodiment credible. The charisma of the machine performer, the presence of the machine body on stage is supported by this alignment. When the body feels animated, mechanical, or arbitrarily assembled, this presence vanishes and is gradually replaced by its sole representation, the object. Therefore, if a lack of presence leads to a perception of behaviours that are solely based on automation, the machine performer will feel animated rather than embodied.

Table 15 shows in summary form how synthetic methodology can benefit from the transformations that occur when we look at multiple levels of embodiment. It must be noted that for a machine designer, the starting point is this Nouvelle AI methodology and it is during the development of the performer that these transformations operate. They are rendered possible because machine performers do not need to implement (in an engineering sense) agency, they only need the presencing of intentions or interpretation. Nonetheless, even if the machine performer does not provide a model or an understanding of an agent, this altered synthetic methodology can open up channels of exploration for eventually deriving a more optimal ecological niche for the agent.

Synthetic Methodology – Nouvelle AI	**Designing Machine Performers based on Nouvelle AI**
The Three Constituents Principle: definition of an ecological niche, definition of behaviours and design of the agent. An ecological niche exploits the environment to create a competence (such as water for fish buoyancy and swimming).	*The Two Levels of Embodiment principle*: the machine performer shall include at least two levels of embodiment; one from the ecological embodiment and one from the social embodiment. Social embodiment is not necessarily seen as a set of supplementary capacities to implement. It can actually short-circuit implementation through fictional or apparent behaviours. Examples: The pain in *La Cour des Miracles*. The dance vocabulary of *Tiller Girls*.
The Complete Agent Principle: 1. Agents are subject to the laws of physics (energy dissipation, friction, gravity). 2. They generate sensory stimulation through motion and generally through interaction with the real world. 3. They affect the environment through behaviour. 4. They are complex dynamic systems which, when they interact with the environment, have attractor states. 5. They perform morphological computation.	*The Complete Agent Principle*: 1. At least two levels of embodiment (see above) 2. Co-presence of an audience 3. Spatio-temporal context 4. A role, representation or character 5. Presencing Examples: *Blind Robot* is a simple piece of mechatronics. However, given the mise-en-scène of the character, the perceived agency and intentionality can be modulated.
Cheap Design: Design must be parsimonious and exploit the physics and constraints of the agent's ecological niche.	*Cheap Design*: The niche can be extended to the social levels, where apparent behaviours emerge in the audience's perception of the machine performer. Example: *Blind Robot* is foreseen as an expert in touch. In reality, his touch is far from being as subtle as a human's. However, it suffices for the audience to engage in interaction with the machine.
Redundancy: agent-different subsystems function on the basis of different physical processes, there is partial overlap of functionality between the different subsystems.	*Redundancy:* machine performer behaviours must align as much as possible the ecological body with the historical/cultural body.

Sensory-motor coordination: enables an agent to interact efficiently with its environment and to structure its sensory input. Both the agent's morphology and its material properties provide physical constraints to significantly simplify the implementation of control architectures.	*Sensory-motor coordination.* Empowering an operator as a sensor-feedback loop element can greatly enhanced the SMC. Example: While developing a machine performer, an operator can trigger activities in the quest of the dynamics of movements or spontaneity of the behaviours. Example: *Tiller Girls* is an improvised performance. *Devolution*'s Spine has better dynamics if triggered by an operator. *Devolution*'s prostheses have a greater richness of movement on the back of a human performer; their actual control is a simple static loop.
Ecological Balance: The capabilities of an agent's morphology (shape, material properties) and its sensor, motor and neural systems have to be carefully balanced. The capabilities are all ecologically balanced vis-à-vis their ecological niche. Control is not limited to the neural system (or the control program) but rather distributed among all these components.	*Ecological Balance*: Control is indeed not limited to the neural system (or the control program) but rather distributed among all these components: the layers of embodiment, the morphologies and the characters. Example: The *Chess Player* was perceived as autonomous and vested with intelligence. Control was borrowed from a human but hidden to the audience.

Table 15. Synthetic methodology and machine performer design

4
Perception and Reception

4.1. Outline of chapter

As the movement of a machine is one of the most prominent factors for the perception of its agency, this chapter will focus on our intrinsic human mechanisms of perception of motion. I will look more precisely at this perception as a phenomenal experience from the audience's point of view. I will also investigate prominent theories and techniques that deal with human perception at the intellectual and phenomenal levels, in order to contextualize my research.

As I have mentioned earlier in this thesis, when an audience perceives an object in motion, principles of animacy, causality and attribution offer a body of theory and corresponding experimental verification concerned with the attribution of intention to this object (Heider and Simmel 1944; Michotte 1963). The psychological experiments found in this field are based exclusively on the motion of abstract objects and are not designed to suggest any direct anthropomorphic associations. In the course of investigating attribution theory, I recreated the Heider and Simmel experiment with the Tiller Girls. The results proved that viewers actually shift their perception of the behaviour of a machine like Stumpy from that of a walker into that of a Tiller Girl dancer. On this level, direct anthropomorphic suggestions do not necessarily imply a positive reaction from the audience, nor a sense of autonomy or agency. In Chapter 2, I argued that the Uncanny Valley is ill-formed mainly due to a misconception of anthropomorphism. Here, I will look at the intangible causes of anthropomorphization found in primal, cognitive and social discourses.

Just to recapitulate, when a machine performer is placed on the stage, the level of its agency is shifted. Extending the vision of nouvelle AI beyond physical embodiment, I investigated how alternative morphologies can engender a phenomenal (visceral) reaction in the audience, and how the biological mechanisms of the perception of human motion can provide grounds of empathy towards inert mechanical bodies. In this process, I looked at the “share manifold” hypothesis, a neurobiological explanation of empathy and embodiment (Gallese 2001). I also looked at point light displays as a technique used to analyse the perception of human and biological motion. I created an experimental scenario combining the two fields in order to evaluate a) whether the shared manifold could be applied to machine performers, and b) whether mechanical motion can transform in principle into biological motion.

For this more specifically psychological section of my research, I have based my observations on practical work staging humans alongside machines. *Devolution* (2006) was a major commission by the Australian Dance Theatre under the direction of choreographer Garry Stewart. Through *Devolution*, I will look at all the machine performers of the company’s cast and reflect on these aspects in relation to theories of human perception. I will examine group movements such as flocking, and situate them within this perceptual realm, and consider the machine performer in the stage space and its contribution to the construction of atmosphere (Böhme 2008).

4.2. Animacy, causality and attribution

The perception of animacy, causality and motion was an important field of research opened up by psychology and neurobiology in the early 20th century. As Albert Michotte suggested, scientific evidence was being accumulated about very simple displays (visual cues) and how they give rise to surprisingly high-level percepts (Michotte 1963). The simplest way to describe perceptual causality and perceptual animacy is to use Michotte's description of the "launching effect" (Scholl and Tremoulet 2000, p. 299):

> (1) Two small squares are sitting in a line, separated by several inches. The first square (A) moves in a straight line until it reaches the second square (B), at which point A stops moving and B starts moving along the same trajectory.
>
> (2) Two small squares are sitting in a line, separated by several inches. The first square (A) begins moving in a straight line towards the second square (B). As soon as A gets close to B, B begins moving quickly away from A in a random direction, until it is again several inches from A, at which point it stops. A continues all the while to move straight towards B's position, wherever that is at any given moment. This pattern repeats several times. (Michotte 1963; Scholl and Tremoulet 2000)

This seems like an objective description based on simple physics and kinematic movement. However, an analysis of subjective perception indicates that it distinguishes two salient situations: in the first situation, A causes the motion of B (causality) while in the second, A and B are seen as alive (animacy), with a certain intention attributed to their motions, such as B trying to flee from A. In Michotte's concept of "functional relations", in which properties are perceived from visual cues (objective environment), he posits that these interpretations cannot be located in either the actual events or their retinal reception.

4.2.1. Heider and Simmel's apparent behaviour experiment

Heider and Simmel expanded the awareness of those fields through the method of testing and collecting animated perceptual responses with different audiences (Heider 1944; Heider and Simmel 1944). They showed that functional relations are primarily perceptual but that their interpretation is highly personalized and individual. They did not set out to investigate facial expressions out of context, or to interpret intention or emotion, but rather to test if situations and activities could be measured by "describe what you see" methodologies. Within this position, they were not looking for correctness of response but for dependence on a variety of stimulus-configurations. The Heider and Simmel experiment protocol was as follows: a candidate was presented with a short animated movie followed by a series of questions. I cite the description of the movie from their publication to exemplify the way they constructed the story. The portrayal uses anthropomorphic words for the purpose of efficiency, since purely geometrical terms would be too cumbersome:

> The large triangle is referred to by T, the small triangle by t, the disc by c (circle) and the rectangle by 'house.' 1. T moves toward the house, opens door, moves into the house and closes door. 2. t and c appear and move around near the door 3. T moves out of the house toward t 4. T and t fight, T wins: during the fight, c moves into the house 5. T moves into the house and shuts door 6. T chases c within the house: t moves along the outside of the house toward the door 7. t opens the door and c moves out of the house and t and c close the door 8. T seems to try to get out of the house but does not succeed in opening the door: t and c move in circles around the outside of the house and touch each other several times 9. T opens the door and comes out of the house 10. T chases t and c twice around the house 11. t and c leave the field 12. T hits the walls of the house several times: the walls break. (Heider 1944, p. 245)

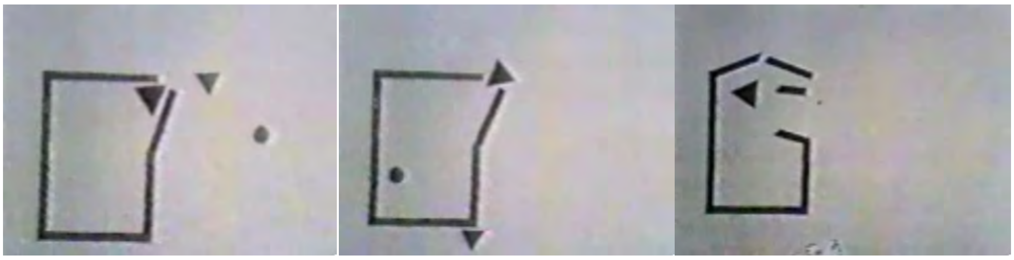

Figure 56. Frames from Heider and Simmel's experiment
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Heider and Simmel built three sets of experiments where the first group was simply asked to "write down what happened in the picture." The second group was asked to interpret the movements of the figures as actions of people, for instance, “What kind of a person is the big triangle? What did the circle do when it was in the house with the big triangle? Why? The last group was shown the picture in reverse with a subset of questions from the second group. Results show that all but a few (less than 5%) interpreted the picture in terms of actions of animated beings, chiefly human.

The researchers interpreted the movement combinations as comprising four categories: 1) successive movements with momentary contact, seen as energetic movements, 2) simultaneous movements with prolonged contact where origin and recipient of a movement induces perception, 3) simultaneous movements without contact where the origin will anchor interpretation such as in leading versus following, and finally 4) successive movements without contact such as chasing or aggressing. They further analysed the perceived origins of movements as causal and need. In causal origins, the movements are organized in terms of acts of persons. In contrast, in cases of need as origin, when a movement is ascribed to a figural unit, this unit is perceived as animated, hence a perception of motive or need arises. However, motivation cannot be read from movement alone, but only with the surrounding field and connected sequences. A figure entering the house can hide, pursue or be pursued, depending on the unfolding of movements. In sum, attribution of origin influences interpretation of movements and the way these figures are judged. The Heider and Simmel experiments have been reproduced recently, and some variation in the description of the characters has been noted, perhaps, as the authors argue, due to growing exposure to animated characters (Lück 2006).

Clearly animacy cannot be separated from concepts of embodiment or of the bodies of primal mechanisms. In their seminal survey, psychologists Tremoulet and School presented current topics about animacy and causality (Scholl and Tremoulet 2000). The results tend to show that the perception of animacy and causality are innately connected in human beings. They introduce a great deal of evidence showing that humans might have several perceptual pathways, hardwired for certain stages of visual perception, while other stages are the result of higher-level cognitive interpretation. For instance, they report a neuroscience study that links perceptual animacy to brain structures in the context of this psychological research experiment. A patient with amygdala damage, however, did not describe a specific movie in anthropomorphic terms, suggesting the important role of the amygdala in social perception (Heberlein and Adolphs 2004).

4.2.2. Reconstructing Heider and Simmel with the Tiller Girls

I devised a small experiment reproducing similar conditions and goals as Heider and Simmel’s 1944 apparent behaviour tests. The aim of this experiment was to verify whether an audience would indeed, as for abstract figures, build narrative structures and endow the Tiller Girls with intentions and attitudes. I was particularly interested to see if gaits would be perceived as dance, i.e. if the machine performer would shift, in audience perceptions, from a functional behaviour (walking) to an intentional behaviour (dancing a specific choreography).

The experiment included some variations on the original procedure. The candidates were first presented with a series of 15 short (ten seconds) clips. Each segment was presented only once and each showed one Tiller Girl robot performing one gait (e.g. turn left, walk forward, crawl). For each clip, the participants were asked to briefly describe the action they saw and attribute an internal state to the robot. The audience was instructed to answer nil if they did not discern any state. Two longer sequences (35 seconds and 1.45 minutes respectively) followed these short gaits. These sequences showed a series of gaits successively linked together with two robots. The machines performed the exact same moves with their respective position constantly altered as a result of their respective movements. After the presentation of the first sequence, people were asked to state “What they saw”. After the presentation of the second sequence, people were again invited to state their perception but they were also asked to describe the two different characters they had just seen in the sequence. I administered the test on three small groups for a total of N=19 subjects, where the gaits and sequences were projected in a single frontal screen before the whole group. All the videos were played silently.

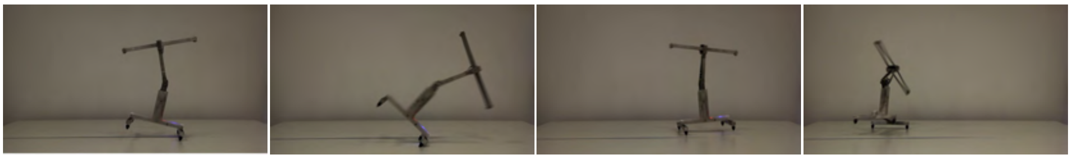

Figure 57. Gaits - Stumping, falling, turn left, dervish

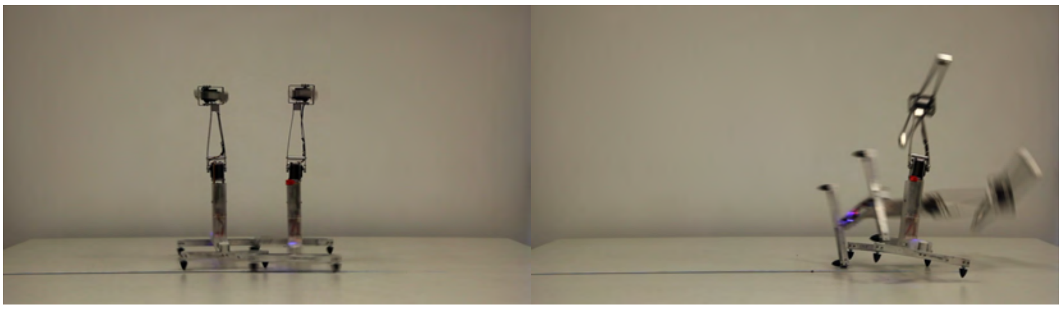

Figure 58. Duets. Embracing (left). Throwing partner on the floor (right)

Among all the observed gaits (15 gaits shown x 19 respondents = 285), only six were described using the word dance (or variation of), which appeared three times for one specific sequence (walking forward and away from the camera). The most striking result was with the narrative sequences, where the word dance appeared 13 times for the first sequence (approx. 68%) and 6 times for the second sequence (32%).

Not only did the presence of a second character induce the perception of animacy and causality in the subjects, but it also transformed a series of successive gaits into dance gestures. Unfortunately the tests did not include a sequence where successive gaits of a single robot were linked back to back, in order to isolate the experimental variables: solo versus duet and single gait versus a series of gaits. Regardless of either variable as responsible for the actual contributing factor in perceiving the Tiller Girls as dancing, both cases would be the result of an act of mise-en-scène. The only case that represents a neutral viewing condition of the Tiller Girls "function" (lab scenario) is the one of single gait where subjects read a negligible amount of movement as dance.

In the two sequences, both Tiller Girls' motors were simultaneously controlled by the same commands. Obviously, the lack of variation in each robot structure, as well as in the floor and in their original starting positions, were among contributing factors that made the robots' behaviour in principle comparable and in fact perceptibly different. This mirroring state was respectively noticed for sequence one and two by 42% and 21% of the subjects. Therefore, in both sequences, the staging makes the characters appear to behave differently (under the same actuation), especially after the breaking points: one protagonist falls off the stage while in the second sequence one protagonist throws the other on the floor. These observations corroborate the results of Chapter 3 where it was seen that the environment cannot be solely ecological but must also include the cultural or social staging of tensions in order to attribute intentionality.

Philosopher Pierre Le Morvan's distinction between three types of intentionality, "transparent", "translucent", and "opaque" (Le Morvan 2005) is useful for an analysis of the apparent behaviour(s) of the Tiller Girls in this experiment. Morvan calls the "intendum" what an intentional state is about, and the "intender" the subject who is in the intentional state. Le Morvan builds the three categories on two criteria: existentially transparent or opaque (condition I) and referentially transparent or opaque (condition II). Condition I grounds the intention: object sighting (seeing objects or events) and factual seeing (seeing facts about objects or events), which are genuinely relational if they entail the existence of not just the intender (the subject) but the "intendum" as well. Condition II enables substitution of identical relations for the same "intendum": if the intentional state is about a, and a = b, then the intentional state is about b as well. Equally, a state is referentially transparent if subject S sees a, and a = b, then S sees b, whether or not S realizes that she is seeing b or realizes that a = b. An intentional state is transparent if it satisfies two criteria. An intentional state is translucent if it satisfies (I) but not (II). An intentional state is opaque if it satisfies neither (I) nor (II).

In the sequences, the internal "motoric intentions" are obviously the same but the environment makes them emerge externally as quite different. According to Le Morvan, and as an intuitive reading, all the actions in the sequences should be transparent. After all, the Tiller Girls can be substituted for each other (Condition II). The perceived intention of a sequence of motoric actions is bound and grounded to the physical object directly by means of morphological computing (Condition I). However, according to the results of the experiment there is breach in condition II, as exactly the same movements in two robots are ascribed different intentions in both sequences (even if they are identical). There is also a potential breach in condition I, as the same movements are seen equally as functional (gaits) or performative (dance) depending on where they are presented in solos or duets. This depends on the strictness with which condition I is applied. Intentionality in these mechanical agents is neither translucent nor transparent, but becomes opaque in terms of their social interactions (at higher levels of embodiment, see Chapter 3.3). Meanwhile, at the motoric level and at the ecological level (interaction with the environment, e.g. at lower levels of embodiment), it should be transparent or at least, translucent.

In sum what seemed an obvious situation of replaceable and substitutable behaviours among a cast of identical objects is not so direct. The emergence of perceived intentions signifies the potential of similar ensembles of robots to generate patterns that would encompass and express the mechanical nature of the origins of the movements. Along these lines, I will explore in Chapter 4.6 how behaviours from non-intentional systems such as swarms can contribute to the creation of "atmospheres" on stage.

4.3. Anthropomorphism

Anthropomorphism within the history of machines, design of objects and theatre semiotics includes a broad array of abstract and representative mimicries of human behaviour. From the beginnings of Greek automata to biomechanics, enhancement via anthropomorphism has played a major perceptual role. Anthropomorphism is an important factor in the arts context.

Anthropomorphism entails attributing humanlike emotional states, behavioural characteristics, or humanlike forms to nonhuman agents. In the 6th century BCE, Xenophanes was the first to use "anthropomorphism" when describing the similarities between religious agents and their believers (Lesher 1992). As Dennett also confirms, the audience often attributed intention to mechanical characters or agents in relation to their predominant belief systems (Dennett 1987).

The close association between the performing machine's visual impact and that of a human agent raises difficult questions not only for artistic practice but also for scientific disciplines. According to Cary Wolfe, both anthropocentrism and specieism reflect the priority of visual reception in the human sensorium (Wolfe 2002).

Today, this attribution raises questions about the level of anthropomorphism needed in robots (Duffy 2003). It also raises discussion in relation to the act of projecting intentions onto performing machines, and questions whether this is an inevitable reflex or not (Duffy and Joue 2005). When comparing attributions to the machine performer in the field of AI, the fictional potentials of the stage have always and always will allow the audience to have associative attributes rather than literal ones. Normally a literal interpretation by the audience is related to the goal-oriented approach of nouvelle AI. However, complex behaviour could emerge from robot morphologies that bear no direct resemblance to zoomorphic entities. This allows for greater freedom in the audience's associations.

I would suggest that behavioural scientist Nicholas Epley's definition of anthropomorphism is more suitable for performing machines. He defines it as a process of inference about unobservable characteristics of a nonhuman agent, rather than a descriptive report of a nonhuman agent's observable or imagined behaviour

(Epley, Waytz et al. 2007; Epley, Waytz et al. 2008). Anthropomorphism is far from being based solely on visual cues, nor does it include behavioural description of observable actions. Describing an observable action, for instance 'this agent is aggressive', does not entail anthropomorphism. It is only when this level is transcended and judgment and attribution are involved ('this agent is vindictive') that anthropomorphism comes in. Hence anthropomorphism does not merely entail animism. Treating an agent as living, animate life is not uniquely a human characteristic. Like any belief, anthropomorphism does not require the reflective endorsement of an inference: for instance, when one curses a computer, because not all will consider that a computer truly possesses humanlike characteristics. A strong form of anthropomorphism arises when one thinks that the agent actually possesses human traits, where weak anthropomorphism (as in the example of the computer) follows a weaker as-if component. Anthropomorphism is not necessarily the result of a mistaken representation of a nonhuman agent, nor does it need to be accurate.

It follows from the above-mentioned characteristics (which are based on Epley's views of anthropomorphism) that when social robotics seeks a "visual anthropomorphism" it is perhaps on the wrong path. Research on the Uncanny Valley and the study of the psychological impact of robots usually formulates questions about the minimal set of visual human features that supplements or augments the functionality of a robot. Formulating the problematic in such terms imply an optimal solution. Anthropologist Denis Vidal investigated anthropomorphism in robotics and in the rituals used to mediate between gods and humans. His findings show that anthropomorphism is far from being optimal in rituals. Objects found in rituals rarely bear any truly anthropomorphic resemblance, nor do they follow the anthropocentric reflex of roboticists that requires any entity that deals with human contexts to act in the same way as humans act with each other (Vidal 2007).

Designer Carl DiSalvo studied the attributes of anthropomorphism when objects are intended and/or perceived as trying to imitate humans. DiSalvo proposes four kinds of anthropomorphic feature that can all be present in a single artefact:

> The Structural anthropomorphic form imitates the construction and operation of the human body with a focus on its materiality. The presence of shapes, volumes, mechanisms, or arrangements that mimic the appearance or functioning of the human body is evidence of structural anthropomorphic form. […] Gestural anthropomorphic form imitates the ways people communicate with and through the human body with a

> focus on human behaviour. It draws from knowledge of human non-verbal communication and reflects the expressiveness of the human body. […] The anthropomorphic form of character imitates the traits, roles or functions of people. It also emphasizes the purpose of individual action. […] Aware anthropomorphic form imitates the human capacity for thought, intentionality, or inquiry. It also recognizes the social qualities of being human. However, unlike the anthropomorphic form of character, which privileges the individual in the society, aware anthropomorphic form emphasizes a common nature of being human. (DiSalvo, Gemperle et al. 2005)

Mechanomorphism would be the pendant of anthropomorphism when we attribute mechanical qualities to humans (or objects). Felicia McCarren in her *Dancing Machines* discusses dancers as machines: “Dancers have represented both the capabilities of highly mechanized body and the pre-technological body whose powerful naturalness is imitated by machinery” (McCarren 2003, p. 4). She considers dance performance as labour: “Arguably important to a cultural reconception of gesture and rhythm in labour, dance offers ways of thinking both about the movement possible with machines and about machines moving themselves” (McCarren 2003, p. 4). The dancing machines of her book are a hybrid between anthropomorphism and mechanomorphism: dancers imagining themselves as machines and machines being imagined as dancers.

In relation to these shifting definitions of anthropomorphism, machine performers and puppets share the essential characteristics of being inert entities that are “animated” and “brought to life” in front of an audience. When Steve Tellis writes about puppet anthropomorphism, he suggests that the verisimilitude in mimicking human behaviour often creates a superficial sense of realism (Tellis 1992). He further suggests that the illusion of life is better supported from movements exclusive to the puppets’ morphology. A comparable argument can be raised in relation to sculptural movement. In his *Morphology of Movement*, kinetic artist George Rickey traces the history of verisimilitude in art and argues that when artists attempt to abstract and stylize form from reality they are often more successful (Rickey 1963). He further suggests that awkwardness and failure to achieve verisimilitude permitted objects to evolve into an artwork. In his terms, kinetic art cannot be served by a direct imitation of nature but by recognition of it laws, awareness of its analogies and response to the vast repertory of its movement through the environment. For instance Jean Tinguely’s 1959 *Métamatics* series of drawing machines imitates the painting gestures of abstract expressionism in an ironic way.

Therefore, the interpretation of robots as performers, or staged robots, involves an act of *suspension of disbelief* as a first and constitutive condition of theatrical reality**.** The puppet as the machine performer takes on its metaphorical connotations because it inherently provokes the process of double vision, creating doubt as to its ontological status: What is the nature of its being? By sharing these ontological[29] questions raised by puppet theorists, and by exploring the paradox of the quasi-living, machine performers force one to define a set of new ontological states that could become future guidelines, in artistic and scientific domains, for both researchers and educationalists (Gruber 1993; Emmeche 1994).

I would suggest that part of the major appeal of machine performers to their viewers is the sense that they are conspecific with them. Like mirror neurons[30], machines are often built to mimic human behaviour, as though the viewers were performing the actions themselves. But appearing conspecific does not entail being structurally anthropomorphic, but rather being metaphorically anthropomorphic in gestures and traits. In their analysis of the coming 21st century theatre, Sermon and Ryngaert cite the many transformations of the human body on the stage since the early 1900s, including disfigured bodies, mechanized bodies, artificial bodies and dehumanized bodies as various attempts to become “anthroponoclast” (Ryngaert and Sermon 2012).

The movement (or perceptible change of state) of an object can be seen as indicating its objective nature, of which the act of perception is the subjective counterpart. Consequently, a rather abstract inert shape can become fluid, organic and eventually anthropomorphic by the sole means of contextualization and movement. In *La Cour des Miracles*, all the robotic performers play the role of miserable machines (begging, convulsing, limping and harassing) using gestural anthropomorphism (see Chapter 1 for figures and descriptions). These deviant machines are shaped to support their hypothetical gestures. The perceived behaviours manifested by these robotic agents are, then, neither real (as no evidence of robot pain has been proved) nor strictly faked, but they are still undoubtedly material and visible. As Epley argues, this

[29] In the context of artificial life, an ontology defines how the world in which the agent lives is constructed, how this world is perceived by the agent and how the agent may act upon its world.

[30] Psychologist Susan Blackmore attempts to constitute mimetics as a science by discussing its empirical and analytic potential.

anthropomorphism does not need to be 'correct', but credibility is greatly enhanced when the audience's response goes beyond mere animacy towards empathy and anthropopathy.

The convulsive machine is helplessly shivering with spasms. The structure of this robot is derived in such way that the actual mechanisms are under a supreme physical stress and tension. This tension percolates into a perceived psychological stress, enhancing the psychophysical unity of the machine. In fact the apparently afflicted bodies are carefully "designed" and "animated" to promote the actuality of their pain which, in turn, foregrounds behaviours over morphologies.

Staging the begging machine anthropomorphizes its perception. Viewers of *La Cour des Miracles* perceive it as a miserable, afflicted creature. With scarcely any computer input, the behaviour is carried out by a juxtaposition of this social mise-en-scène and the gestural anthropomorphism of the character. Starting from a weak anthropomorphism (a box should have no affliction), the anthropopathy towards this machine and its consequent degree of credibility increases in strength. The begging machine's body is not anthropomorphic, but elements of its anatomy recall parts of the human body, for instance the arm that grabs the money. Actually it is the gestures that provide the anthropomorphism here. The body's trunk is a structure inspired by a (treasure) chest but its rocking movement mimics that of a beggar. The robot starts with a weak anthropomorphism in its structure, the gestures make the anthropomorphism stronger, and finally the contextualization raises the level to an actual anthropomorphization of this machine performer as a beggar.

4.4. Perception of human movement

There has been rising interest recently in the perception of dance – human movement – and its potential relations with the mirror neuron systems (MNS) of the brain (Hagendoorn 2005; Reason and Reynolds 2010; Jola, Ehrenberg et al. 2011). Dance analysis is focused not so much on the imitative powers of MNS as on the potentials of empathy bound to what Vittorio Gallese has called the shared manifold hypothesis (Gallese 2001). Lying at the root of phenomenal identification with the dancing body on stage, this hypothesis resides in the human ability to perform an embodied simulation (Gallese 2005).

In this section, my aim is to construct a similar hypothesis for the perception of the machine performer. As studies in MNS have mixed results about the systems' activation when watching a non-human (or non-biological) agent, I will have to investigate possible correspondences between machine and human performers. Regardless of whether the shared manifold hypothesis can be solidly proven or not, the establishment of pathways between the perception of the human and the mechanical body might provide a rationale for our visceral reactions to machine performers (as in *La Cour des Miracles* or with *Tiller Girls*). As I have demonstrated with regard to the powers of anthropomorphic suggestion, the perceptions concerned are intellectual. Studying the perception of the machine performer's movements addresses a complementary process.

4.4.1. Embodied simulation, body schema and correspondence.

For Gallese, the same neural structures are involved in our conscious modelling of our body acting in space as in our awareness of living bodies and objects in the world. Gallese also argues that other neural circuits guide the sensations and emotions in and through which we experience and interpret actions performed by others, and understand the emotions and sensations they experience. Basically this is the neural route of empathy based on a mutual understanding of social and cultural codes found in human gestures. This hypothesis proposes, therefore, that we understand actions by a process of simulation, against a personal background of emotions, within our own bodies.

To create this awareness, neuroscientists refer to the concept of "body schema" and "body image" (Gallese 2005). The body schema is an unconscious body map that is used to move and monitor the actions of our body parts. In contrast, the body image is a conscious perception of our own body. The body schema operates at the physiological level while the body image corresponds to a phenomenological level. Relating this to Chapter 3, robots of nouvelle AI have a body schema, and in my works I suggest that machine performers have (i.e. create) a body image.

Gallese states that our social competence is based on the meaning of the actions we witness. These fall into two categories: transitive, object-related actions (grasping a mug) and intransitive, expressive or deictic action (sending kisses). Gallese points out:

> What makes our perception of both types of actions different from our perception of the inanimate world is the fact that there is something shared between the first and third person perspective of the former events; the observer and the observed are both human beings endowed with a similar brain-body system making them act alike. (Gallese 2005, p. 32)

Meaningful conceptual structures arise from the structured nature of bodily and social experience. They also arise from our innate capacity to imaginatively project from certain well-structured aspects of bodily and interactional experience to abstract conceptual structures (Lakoff and Johnson 1999). Given the observations made in this section, we may conclude that a robot with wheels, as opposed to legs, would lead to very different bodily reactions in the audience. Hence the role of the designer is to endow both structures and movements of the machine performer with some level of shared mutual bodily understanding with the audience.

4.4.2. Correspondence

The correspondence problem is an important issue in imitation by agents. Dautenhahn and Nehaniv posit this problem as being like a "given animator (a biological or artificial system) trying to imitate a model (the biological or artificial system to be imitated)", and ask: "how can the imitator identify, generate, and evaluate appropriate mappings (perceptual, behavioural, cognitive) between its own behaviour and the behaviour of the model?" (Dautenhahn and Nehaniv 2002) For instance, structural homologies among tetrapod animals and artefacts could link the head, the feet and the hands. In a similar fashion to the body-map, the imitator has to identify structural correspondences.

However, even systems with very dissimilar bodies (and body-maps) can achieve the same behaviour. In this case, the authors give the example of hovering as common to a hummingbird, a helicopter and a hoverfly (syrphid fly). Mimicking or copying presupposes a notion of correspondence between agents. Dautenhahn and Nehaniv tend to focus on the formalization and algorithmic implementation of the problem for artificial agents. Nonetheless, the way in which the mirror neuron system mediates relations between actions of agents on their environment may well also be relevant to the investigation of this correspondence.

4.4.3. *Point light displays*

We rarely have to rely on animate motion alone to generate shared bodily understanding or correspondence, as multiple cues are usually present at the same time. In order to isolate the visual perception of biological motion, Gunnar Johansson introduced point light displays (PLDs) into experimental psychology some 40 years ago (Johansson, 1973). Replacing the normal visual cues of a human body by a small number of dots matching the major structural points of the body, these create a vivid percept of the human body (Johansson, 1976). With such point-light walkers, experiments found that participants can attribute gender to a walker and identify individual persons. Although this effortless organization of a small number of moving dots into the coherent percept is well documented, the underlying mechanisms are still poorly understood (Troje, Westhoff et al. 2005). Point light displays (PLD) also offer a technique to investigate the isolation of movement from anthropomorphic visual cues, rendering the body as an abstract structure or morphology.

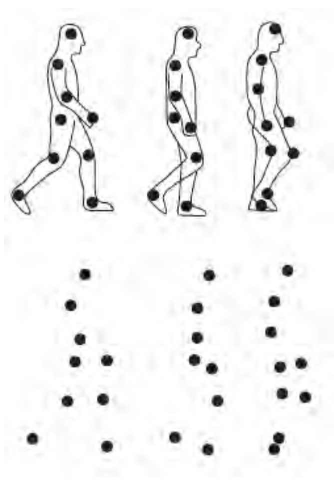

Figure 59. Point light displays for human movement (Shiffrar 2011)
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On the analogy of biological motion, point light techniques can also be used to study non-biological motion. Pyles and Grossman's experiments are based on synthetic creatures derived from evolutionary algorithms. The study examines behavioural and neural responses to novel, articulated, non-human ”biological motion”. The researchers found that artificially evolved creatures can effectively portray animate events, even when depicted only as point-lights (Pyles, Garcia et al. 2007; Pyles and Grossman 2009).

As each creature in these experiments represents a different model, observers must build the body representation anew each time from implied cues. Pyles and Grossman point out that

> […] body structure is much more informative for human point-light animations in which the same body configuration can be anticipated regardless of the action depicted. Prior assumptions regarding body structure will be less informative for the Creature trials as compared to the human trials. (Pyles, Garcia et al. 2007, p. 2795)

Finally, their results on neuroimaging are not congruent with each other with respect to the way the brain regions are triggered when watching the PLDs of humans and of what Pyles and Grossman call “creatures”. They suggest that there is evidence for neural mechanisms of perception that processes novel dynamic objects such as non-human creatures.

With colleague Chouchourelou, Margie Shiffrar, an authority on the perception of motion, compared stimuli from biological (human and animal) and non-biological sources in order to expand on previous observations that percepts of biological and non-biological objects are neurologically dissociable. The PLD technique has been mainly used for human gait and it is far from clear how this can be generalized to nonhuman movements. Chouchourelou and Shiffrar report that

> The visual percepts of human motion and object motion typically differ from one another dichotomously while the percepts of human motion and non-human, animal motion vary smoothly along some continuum. That continuum appears to be graded in a manner that reflects the degree of similarity between an observed event and the observer’s ability to produce that event with his or her own body. (Chouchourelou, Golden et al. 2013)

It is suggested that this gradient may be defined by the degree of bodily similarity between the observer’s own body and observed bodies:

> Indeed, observers in the simple studies described here consistently demonstrated greater visual sensitivity to some non-biological entities, such as cars, than to some biological entities, such as the apedal bodies of fish and snakes. Interestingly, when non-biological objects, such as wooden blocks, are positioned so as to mimic the structure of the human body, observers tend to interpret the movements of those non-biological objects as if they were actually human movement. (Ibid.)

Despite the observation of these specific cases,

> [t]he results [of their experiment] are consistent with the existence of a perceptual category that might be called "biological motion" that includes at least people and animals but not human made objects. Within this proposed category of "biological motion", human movement appears to constitute the best or prototypical stimulus that yields the greatest neural activity within the action perception system as well as relatively elevated perceptual sensitivity. (Ibid.)

4.4.4. The Tiller Girls' body schema.

In order to investigate if there are phenomenological levels where a human audience could identify with the Tiller Girls, I sought to establish whether or not there was any form of correspondence between the Tiller Girls' body schema and that of humans.

In this experiment, I am trying to see if the "shared manifold" hypothesis can be verified by the audience's biological perception of the movement of the machine performers on stage. I can also test the possibility of modulating the perception of mechanical motion and shifting it into the realm of animal motion. The experimental results demonstrate that participants recognize alternative locomotion patterns in some special cases of the Tiller Girls' PLDs, and also that any structural correspondence suggested between humans and Tiller Girls disturbs the classification of some Tiller Girl gaits.

Figure 60. Motion capture of Tiller Girls

The generation of the PLDs of the Tiller Girls was done in a dance studio using motion capture recording systems. Only one robot was recorded at a time. I made three sets of recordings with a different number and location of light points on the robots. The recordings with nine points are the fullest and most literal representation of the Tiller Girls' morphology, virtually mapping the points where their four feet touch the ground. Two other in-between scenarios utilize six points, the first with the shoulders and feet points aligned (two opposed T's), and the second with only the extremities aligned (two opposed V's).

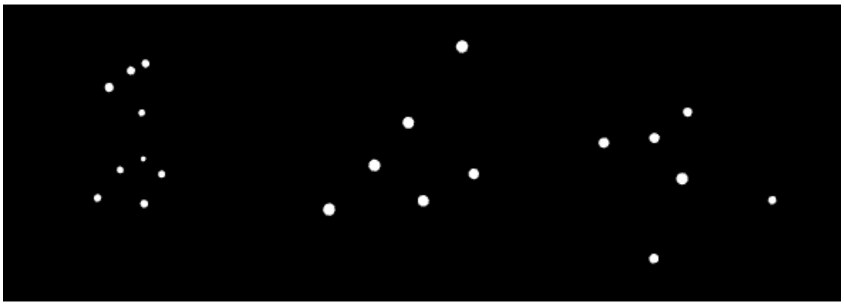


Figure 61. Tiller Girls' PLDs. Four legged vs. two legged bodies

In the spirit of the previous Shiffrar experiment, the test consisted of 15 different PLD sequences with each lasting around three to four seconds. The clips were played three times in a row. There was one clip for training the subjects. The clip was a human walking normally. The subjects were asked to determine if the movements they saw were mechanical, animal or human in nature. Subjects were instructed to assign "other" if they could not categorize what they perceived and, if they wanted to be more specific (e.g. insect as opposed to animal), to write their alternative perception. The subjects were also asked to label the action and give the direction of the perceived movement. I administered the test to three small groups for a total of N=19 subjects where the PLDs were projected in a single frontal screen before the whole group. All videos were played silently.

The 15 clips comprised five human, four animal and six mechanical movements. The human actions ranged from the simple (jogging, cartwheel and sidekick) to the complex (performing push-ups and crawling on four legs). Among the five animals, none were bipedal (dog walking and seal crawling) and two were apedal (owl and bat flying). All the clips except the mechanical ones were taken from an existing database made by Tomas Shipley's Spatial Cognition, Action, and Perception Lab at Temple University[31]. All the mechanical PLDs were extracted from the Tiller Girls' motion capture. Two out of the six sequences utilized the "four legged" Tiller Girls and the others, the double V configuration.

For a sub-group, prior to the training video, I presented the image of Figure 62. This image suggests a potential mapping that is transferable from the human figure to the Tiller Girls: it aims at establishing a correspondence between human shoulders and arms and the upper T structure of the Tiller Girls and also between the human waist and legs and the waist and feet of the robot. I selected the double V point light displays as opposed to the nine points, so the suggestion does not refer to an obvious mechanical artefact.

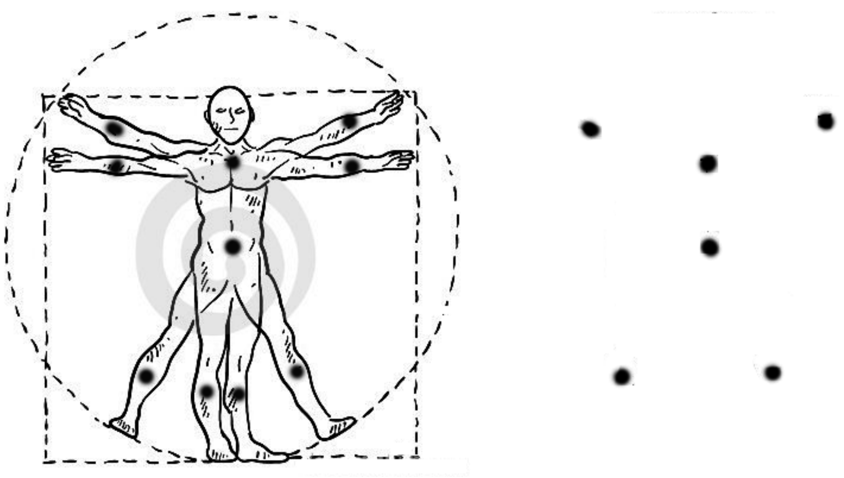


Figure 62. Suggestion for mapping – experimental variable

Figure 63 and Figure 64 report the success rate of identification of the object in motions. These results are comparable with the results from Shiffrar depicted in Figure 65. Complex human movements are confused with mechanical ones in the Shiffrar study and with animal movements in my case. There is a remarkable difference for apedal animals. In my experiment, the wing flapping of flying animals was rather easy to detect, while Shifrar's tests included swimming motions, which are more intricate and difficult. Mechanical objects seemed to be identified by the majority of participants in both studies.

[31] http://astro.temple.edu/%7Etshipley/mocap.html

Observer categorization response	Human (simple)	Human (complex)	Animal (walking)	Animal (flying)	TillerGirls (four legs)	TillerGirls (two legs)
Human	0.96	0.24	0.26	0.03	0.03	0.11
Animal		0.39	0.61	0.61	0.08	0.20
Mechanical	0.04	0.08	0.03	0.03	0.82	0.54
Other		0.29	0.11	0.34	0.08	0.16

Figure 63. Success rate by category and stimulus type

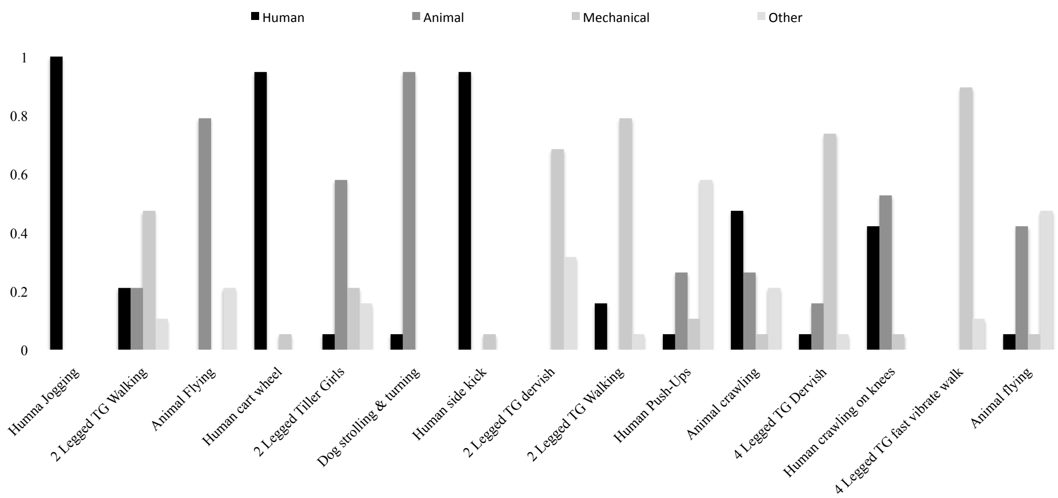


Figure 64. Success rate for each clip, by category of stimulus

Observer Categorization Responses	Experiment 1: Stimulus Category				
	Easy Human Actions	Difficult Human Actions	Bipedal Animal	Apedal Animal	Mechanical Object
Human	80.5	37.7	38	14	10.3
Animal	21.5	16.3	41.5	10.3	25
Mechanical	6.8	37	10	18.7	47.5
Other	1.2	9	10.5	57	17.2

Figure 65. Success rate by stimulus (Chouchourelou, Golden et al. 2011, p. 5)
Permission to reproduce this figure has been granted by the authors.

The main results are that the two-legged Tiller Girls are perceived as less mechanical than the four-legged ones, and that the suggestion for equivalences between the human body and the two-legged Tiller Girls had some influence on their categorization as non-mechanical. Among the four sequences including the two-legged robot, three had their most frequent responses miscategorised. In the upright walking position, the robot perceived as walking is more frequent in the group exposed to the transfer suggestion indicated above. In its crawling position, the exposed group perceives the motion more as animal than the non-exposed group. In its rotating dervish motion, most members of the exposed group see the robot as an animal, while the non-exposed group clearly stick to a perceived mechanical gesture.

Tiller Girls two-legged Observed as G1 - non-exposed G2 - exposed	Walking	Crawling	Dervish	Walking
Human G1		0.11		0.11
Human G2	(*) 0.40			0.30
Animal G1	0.11	0.44		
Animal G2	0.2	(*) 0.70	(*) 0.56	
Mechanical G1	0.67	0.33	0.80	0.78
Mechanical G2	0.30	0.10	0.44	0.70
Other G1	0.22	0.11	0.20	0.11
Other G2		0.20		

Table 16. Correspondence impact on two-legged Tiller PLDs

This experiment still needs to investigate the scrambling and noise factors that are a norm in the PLD studies of human motion. As building a fully-fledged PLD test would be a large enterprise involving programming and motion capture of many subjects and objects, I did not want to exclusively devote the perception chapter to this topic. The tests presented here were made in the spirit of verifying whether the correspondence problem can be in part analysed with the help of point light displays. The outcome is modest though promising, whereas to fully investigate this avenue would require further analysis of the repercussions of the number of points on a moving body. The motion capture of both human and machine bodies should be made in concert with equivalences already established prior to the recordings. Finally, the distribution of the points on the body must be carefully assessed – for instance, in the example of the Tiller Girls a nine point cloud screams mechanical construction, while a six point structure brings some freedom in the interpretation of the moving dots.

4.5. Atmosphere

This tension between authenticity and representation, a classical principle in visual aesthetics that informs any mechanical simulation of the animate, can readily shift towards the creation of atmosphere. The concept of atmosphere holds a series of opposites – presence and absence, materiality and idealism, the definite and the indefinite, singularity and generality – in a relation of tension (Anderson 2009).

When Boehme introduces *atmosphere* as a new form of aesthetics, he situates its origins:

> The conception of atmospheres as a phenomenon has its origin in reception aesthetics. Atmospheres are apprehended as powers, which affect the subject; they have the tendency to induce in the subject a characteristic mood. They come upon us from we know not where, as something nebulous, which in the 18th century might have been called a *je ne sais quoi*, they are experienced as something numinous – and therefore irrational. (Böhme 2013, p. 1)

He formalizes this *je ne sais quoi* under a phenomenological perspective:

> Atmosphere is the common reality of the perceiver and the perceived. It is the reality of the perceived as the sphere of its presence and the reality of the perceiver, insofar as in sensing the atmosphere s/he is bodily present in a certain way.(Böhme 1993, p. 122)

Atmospheres synthesise and at the same time legitimize the particular forms of speech in which an evening is called melancholy or a garden serene (Böhme 1993). Boehme claims that classical aesthetics dealt practically with only three or four atmospheres, for example, the beautiful, the sublime and the characterless or “atmosphere as aura”. Under Boehme’s definition there is an endless variety of atmospheres: serene, serious, terrifying, oppressive to name a few. The multitude of linguistic expressions indicates that a more complex knowledge of atmospheres exists than is suggested in aesthetic theory.

When approached from the side of production aesthetics, which makes it possible to gain rational access to this “intangible” entity. Boehme claims that

> It is the art of the stage set which rids atmospheres of the odour of the irrational: here, it is a question of producing atmospheres. This whole undertaking would be meaningless if atmospheres were something purely subjective. […] It is, after all, the purpose of the stage set to provide the atmospheric background to the action, to attune the spectators to the theatrical performance and to provide the actors with a sounding board for what they present. The art of the stage set therefore demonstrates from the side of praxis that atmospheres are something quasi-objective. (Böhme 2013, p. 2)

Atmospheres are not things and they are always perceived by subjective experience. However, the quasi-objectivity of atmospheres is demonstrated by the fact that we can communicate about them in language and that the stage set is a practical proof.

A further pertinent insight about environments created for (or by) machine performers is Svoboda's conception of theatrical and scenic mosaics, which transform spatial perceptions, and his notion of what he termed *psychoplastic* space:

> My essential point in using projections is the creating of new stage space, not as a substitute for *decor* or establishing a locale. […] we want to attempt composing individual, separate, and distinctive visual perceptions into a new total-image according to a given theme: to convey a given intention by a composition of images, their inter-relationship, their temporal and spatial rhythm. […] The result is real psycho-plastic space created by transforming the dimensions of space in response to the nature of the scene. (Burian 1971,pp. 93-95)[32]

Applying atmosphere to (and with) machine performers is recurrent in the late 20th century. Science-fiction movies are permeated with utopian or dystopian sensations rooted in apocalyptic scenarios. Icons of the creation of machine mayhem, the performances of Survival Research Laboratory (SRL) are staged in warehouses; the sound level is unbearable and the performance usually ends with the entire environment being destroyed. What people communicate about SRL is the atmosphere they create.

In my own works, the scenography is an integral part of the machine performer, just as it is one of the constituents of its environment. Conversely, I use the machine performer as a stage element to create atmosphere. For instance machines can become lighting instruments (with intentionality) or dynamic décor. Their labour and energy are then part of the atmosphere created. In the practical works found in this thesis, *La Cour des Miracles* is in itself an atmosphere. The scale of *Area V5*'s array of skulls augments the atmosphere of surveillance, and the *Tiller Girl* theme sets the tone of the whole performance.

[32] Burian actually quotes Svoboda in the presentation of these spaces.

4.6. Case Study: *Sayonara* and *Pessoa*

Figure 66. *Pessoa* (Ubu Theatre, 1997) and *Sayonara* (Hirata, 2011).
Permission to reproduce *Pessoa* image has been granted by the Ubu Theatre. Permission to reproduce *Sayonara* image has been granted by the Ars Electronica.

Recently, there has been interest in a theatre play that involves a female geminoid (produced by Ishiguro's laboratory). In the following brief analysis I will contrast my concept of the machine performer with, and distance it from, that of *Sayonara*'s humanoid performing on stage.

The two theatre performances, *Les Trois Derniers Jours de Pessoa* by theatre group Ubu, and *Sayonara* by director Oriza Hirata, share quite a few aspects. First they each stage two characters, one human and the other his/her artificial counterpart. Second, the artificial characters are not mobile and their movements are "off-line", i.e. pre-recorded for Ubu's piece and tele-operated for *Sayonara*. Third, the robotic artist Zaven Paré, currently working with Ishiguro, participated in the production of both performances (Paré 2011; Paré 2012; Paré 2013). I interviewed Paré about both these experiences.

I had the opportunity to see both performances live, and while the adaptation of *Pessoa* constantly engaged me, my interest in Ishiguro's work was almost non-existent. I had neither a sense of the uncanny in Ishiguro's work nor any sense of co-presence. However, I had a pleasant sensation of eeriness from the ghostly presence of the video puppet in the *Pessoa* performance.

At the ICRA 2012[33] workshop, I participated with Ishiguro as an invited lecturer discussing the potential of robots for the arts, and specifically for performance. Ishiguro himself portrayed the geminoids as “big speakers with a human shell”. Indeed, in both performances, the artificial creatures are nothing more than a speaker with a human shell. What made me attracted to Ubu’s work and not Ishiguro’s? A starting point for the difference lies in the characters. Pessoa is the ghost of a human; in fact, the main protagonist has a conversation with himself on his deathbed. The actroid is a robot playing the role of social robot character, accompanying the main protagonist through her terminal disease. In *Sayonara* I felt stuck between an experimental laboratory[34] and a demonstration of the capabilities of the actroid.

From the point of view of the orders of presence and representation, this actroid plays the role of an android, which means that the order of representation is cancelled and the object represents itself. When it comes to *presence*, the android is too functional, reducing to a dressed-up radio capable of a few facial and bodily expressions. Although the android recites the text (poetry) with hints of credible emotion (like embodying indifference in an emotionless character), it is not *present*. By anthropomorphizing and instrumentalizing indifference and sentimentality in the recitation of poetry, the android fails where it wants to succeed.

Hibino’s analysis of *Sayonara* sees the central character as multistable, oscillating between authenticity and fakery (Hibino 2011). However, my perception of the situation is radically opposed to this claim. There is only one suggested reading of the embodied emotions or behaviours of an android, and this offers barely any of the perceptual richness of Fischer-Lichte’s multistability: it is a robot playing a robot in the sentimental story of the relationship between a robot and a dying human. Here the orders of both representation and embodiment are fixed. These are human representations (and stereotypes) rendered in a functional way by a mechanical speaker. And although the audience realized that it was a matter of a mechanical device trying to achieve a fake sentimentality, they chose to pick up the monotone dissonance of a humanoid playing a humanoid.

[33] International Conference on Robotics Automation
[34] Ishiguro is collecting survey data about the performance.

Oscillating between fakery and authenticity, in the context of Orizo's and Ishiguro's play would lead an audience to consider that the android has a presence on stage, incarnating a character that transcends the android's sole perceived function (mainly a speaking human body with minimal facial reactions). As opposed to what Ishiguro claimed at ICRA, I would argue that audiences are not duped by the geminoid. The geminoid is a machine and is perceived as a machine throughout the play. I would argue, in opposition to Hibino's analysis, that a machine that can recite poems does not manifest the fakery of a performer. As Ishiguro himself wrote, an automaton saying "thank you" is more aligned to the behaviour of a stage performer than to that of a robot playing the character of a robot.

One can certainly claim that the video playback device (the machine performer of Ubu's play) would fall under the analogy provided by Ishiguro's incarnated speakers. Theatre theorist Liviu Dospinescu discusses the effect of presence and non-representation in Ubu's work and claims that contemporary theatre is looking at experimental ways of generating presence (Dospinescu 2008). Ubu's work displaces the concept of the actor, replacing it with a video projection (Jacques 2005). The actors brought back on stage by this technological means have a different presence, but they effectively inhabit the dramatic space: the liminal divide between life and death. As Dospincescu argues, the absence of real actors paradoxically heightens the sensation of their presence.

Actual Body (below) vs. Staged Representation (right)	Human	Humanoid
Human	Acting	Stereotypical indifference. Incongruence in emotions. Stereotypical gestures.
Humanoid	Breach of believability. Substitution bound to fail to the competence of an agent "out of its niche". Typical science-fiction character.	Surreal sense of authenticity. Potential implosion of the representation and presence.

Table 17. Humans and humanoids playing each others' roles

4.7. Contributing work: *Devolution*

The Australian Dance Theatre – via their artistic director Garry Stewart – commissioned my first contributing work during this thesis: De*volution* (2006). The work is a dance performance for metallic and organic performers, in which thirty robots share the stage with ten dancers. The atmospheres produced by my previous works compelled Stewart, and in *Devolution* a singular metaphorical universe is amplified by a compelling sense of ritual that drives the form and aesthetics of the work. The structured repetition of the robotics suggests a rite of passage, evoking communality and the metaphysical. The work is richly embedded with symbols of transformation.

4.7.1. Description of work

The nature of consciousness, the perception of emotion and intelligence, of what is living and dying, and how empathy is evoked are the starting points for *Devolution* and its choreographer Garry Stewart. In an early proposal for the work, Stewart presented his position: "The work operates through an overt sense of ritual with the suggestion that for all of our technology we are still primitive, and of the flesh. We continue to engage in religious ritual and we remain biological entities" (Stewart 2004).

As performing entities, Stewart continues, the robots are given equal status to the human bodies in the work, albeit with some major operational differences. *Devolution* does not try to conceptually separate robots and humans as different species, but it is interested in the collision and confluence of the two. When they collide, *Devolution* becomes an experiment in morphology and function: we acknowledge the robots as machines and in doing so we explore the machine-like function of the human body and the zoomorphic potential of bodies. By distorting the body away from an upright bipedal orientation and challenging the Cartesian view of the body, *Devolution* posits humans as animals, which of course we are. It then explores the anthropomorphic potentialities of robotic machines, the nature of human consciousness and thought, and the emotional potential elicited by machines in relationship with human performers. The work is a fantasia set in its own universe populated with human and machine-made symbols suggesting, as Stewart puts it, deities, angels, creatures and totems. Furthermore, it evokes the image and function of a closed ecosystem embodying processes of mutualism, symbiosis, hierarchy, sickness, birth and death.

The work situates humans in communion with both large and small-scale robots, and forces us to create a relationship between the two. Through *Devolution*, Stewart and I looked at human bodies and the role of consciousness and human emotions, as they co-exist next to machines that are devoid of feeling. Simultaneously, the machines were designed and operated so that they purposefully aimed to evoke "feelings" and "emotions" and gave the appearance of being motivated by thought. This is in conflict with our concept of machines as spiritless and "dead".

In the lineage of my works, *Devolution* explored different facets of the anthropomorphic, zoomorphic and mechanomorphic characteristics of the machine performer, so that the audience felt empathy and identity with them. Audiences seemed to elicit emotional and psychological content, which was in reality produced by viewing the machine performers subjectively through the paradigm of our own experience as emotion-and-thought-oriented beings (dancers and machine performers). In *Devolution*'s proposal, Stewart concludes:

> What is this saying about consciousness and perception? What is this stating about the rationale for movement and gesture? The machines don't actually care what we think about them, they have no conception of our existence or their own. Yet at the same time, human beings are also machines, with cables, a central pump, electrical wiring etc. Present in every machine is the metaphor of the human body. (Stewart 2004)

Devolution is a surreal and rich parallel universe that evokes images and functions of a closed ecosystem embodying processes of mutualism, hierarchy, territoriality, parasitism, predation, symbiosis, senescence, sickness, birth, death and growth. *Devolution* explores the anthropomorphic potentialities of robotic machines and the nature of human consciousness and thought. It also explores the emotional potential elicited by machines in relationship with human performers.

Looking at the dancer-machines of *Devolution*, we see a world in which we may no longer be human, if being human means being masters at a distance, different and disconnected from all that we survey. Looking at *Devolution*, we learn instead to live our lives embedded in and enmeshed with the beings of our world. *Devolution* creates a ritualistic drama that disrupts the centrality of humans, inasmuch as they share time and place with their mechanical creations. It triggers the sense of pleasurable disruption and irrationality at seeing an object move with what seems like decisive purpose and conviction. As humans we find a pathos in the actions of these machines that allows us to feel for the struggle they appear to be enduring in enacting their simple function. Their struggle is read and understood through our own struggle. Empathy is immediately evoked. There is a symbiosis between metal and flesh, as the robots are an attempt to express the profoundly human nature of the mechanical realm and the profoundly mechanical nature of humankind. As the performance programme puts it, to dance with machines is to dance the ecology of our world.

4.7.2. Aims

Devolution aims:

1. To create a relationship between performers and large-scale robotic machines;
2. to force the audience to create a relationship with large robotic machines;
3. to explore various morphologies of the machine performers and their underlying characteristics so that the audience would feel empathy for them;
4. to construct an interplay of bodies: human, mechanical and part human, part machine with the goal of eliciting emotional and psychological content which is, in reality, produced by viewing them subjectively through the paradigm of our own experience as emotion-and-thought-oriented beings;
5. to create a sense of the unreal through ritualistic drama, because this genre disrupts the centrality of humans in live performance, as they share time and place with their mechanical creations;
6. to investigate and compare the quality of presence from machine and human performers sharing the same stage;
7. to investigate how organized groups of machine performers can create atmospheres and a genre of psychoplastic stage[35] – the redefinition of scenography in the 20th century.

Before embarking on the analysis, I will provide some insights into the process of designing, producing and rehearsing with machine performers.

4.7.3. Design and development of Devolution's machine performers

[35] Scenographer Josef Svoboda coined this genre (see section on Atmosphere)

1) Choreographer's framework

In this section, I will trace the process of developing the robots for *Devolution*. The piece works with the dancers exploring choreographic relationships that respond to ecosystem processes. The choreographer and director started with this framework of ecosystems that became pivotal for the whole design process. Furthermore, to explore the relationships of beings within the ecosystem, Stewart and I investigated the processes of mutualism, parasitism, symbiosis, mutation, hierarchy, territoriality, predation, swarming, herding, carnality, sickness, birth and death (Zimmer 2003). By engaging in a closed invented ecosystem embodying these processes, we attempted to create a ritualistic drama that disrupts the centrality of humans as they share time and place with their mechanical creations. Looking at *Devolution*, spectators may learn instead to live their lives embedded and enmeshed amongst the beings of a world in which machines are now an integral element.

In the design brief, Stewart was equally attracted to the monumental scale of my previous works, where he wanted to incarnate large scale machines that would act as metaphors for deities, angels and totems. He was also interested in small to medium-sized robots that would interact directly with the dancers and can enact contact duets and trios with them. Finally, Stewart was looking at a ”kinetic stage” – a stage-wide robotic environment that would act as an overarching context for the work.

2) Interpreting the director's framework

In an interview with Stewart, I revisited the development of the robots and we discussed their fulfilment of the original concepts of the work. Stewart reflected on the ongoing discussion we had had about the strategy of developing simpler and more varied machines versus concentrating on fewer but more articulate mechanical bodies, closer to human dancer capacities. I reminded Stewart that ecologies rely on diversity and the failure of one species should not compromise the whole ecosystem, as might be the case with a single complex machine performer. The choreographer had to adapt the rich movement vocabulary that he employs with human dancers and to "distribute" it among the machine performers. I had to persuade him that the intrinsic qualities of the machine performers that I could technically achieve were not situated in virtuosity but in its limitations. The challenge is not to create a situation where the machine, as a manifestation of a lowest common denominator, impedes its capacity for stage presence.

Staging for dance is a mixed blessing, as an open and empty stage is a flexible canvas. However, for Stewart this stage had to remain clear, as his dancers needed a minimal volume (extending to a few metres high for their jumps) to execute acrobatic drastic, precise and extreme movements. Therefore, most robots have to enter and exit the stage for their stage appearance, either from the ceiling (flying), from the wings or from an upstage position away from the dancing area. What sounds like a simple requirement is already a challenge for robots as, on top of being able to "dance", they would need to be mobile and able to navigate on stage.

I proposed more than thirty machine possibilities during the early stages of the development of *Devolution*. During that period, Stewart and I had occasion to experience each other's work. Stewart visited my atelier and experienced the co-presence of some of my previous machines, and I attended several ADT European performances during that period. We finally agreed on the development of eight different groups of robots that would respectively target the initial concepts of *Devolution* with the provision to drop groups due to unforeseen events at the production stage. Among the six species listed below that were finally part of the premiere, the first three species were targeted at the kinetic stage and the creation of atmosphere while the last three were designed to interact with the dancers:

1. The Cube. A metaphor of Greek theatre's *deus ex machina*, a god-like entity morphing into an organic network. The Cube is based on a rigid discrete manipulator. Once animated, a strong cognitive dissonance emerges from a massive abstract structure that morphs into an organism that softly floats above the stage.

2. The Chorus is the most anthropomorphic robotic entity, though it is sketched down to its elementary form. The Chorus manages to interact with minimal human gestures mainly derived from its neck and head.

3. The Swarm is a colony of insect-like robots. Based on a flexible symmetrical structure, they can navigate in all directions (Chen and Yeo 2003).

4. The Spine is a complex structure based on the assembly of several parallel manipulators. The structure and movements recall the morphology of a disembodied spine.

5. The Big Bots are two large hexapods, spanning over four meters, gliding slowly across the stage. Despite their large bodies, these robots interact softly with dancers.

6. The mutations or malformations, incorrectly labelled prostheses, are seen as the initial phase of a hybrid metallic and organic evolution. They can also incarnate a host-parasite relation, distorting, disturbing and convoluting the human body in action. Articulations of the mutations are based on a parallel manipulator, enabling full revolution around the joint. These “prostheses” are worn by the dancers and alter their proprioception, creating a symbiotic-antagonistic relationship between dancers and technology.

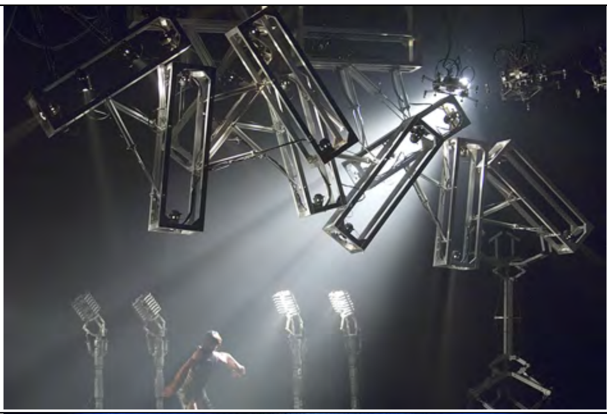
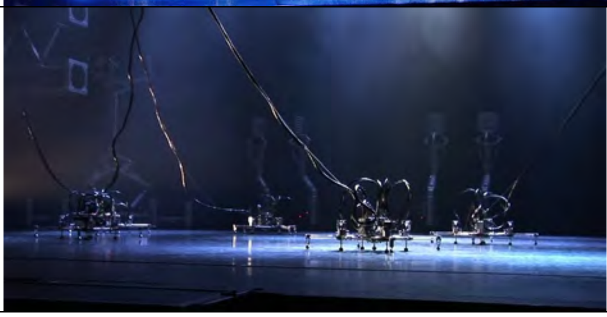
Borrowing items such as variable geometry trusses, discrete manipulators and parallel manipulators from the mechanomorphic realm, each of the robot species reformulates these inert shapes into life-like bodies (Hughes, Sincarsin et al. 1991; Merlet 1993 ; Suthakorn and Chirikjian 2001). The design process of the robots is to replicate non-organic robot geometries that were originally made to serve a purpose (a functional tool) and reappropriate them into one of the machine performers to endow it with some degree of intentionally and agency. I also decided to replicate body parts across the robot species, to suggest on the one hand common building blocks inside this fictitious evolution process, and on the other a process of synthesis, yet with some degree of diversity. For instance, articulations (neck, shoulders, elbows) are all based on the same mechanical architecture (Chirikjian 1994).

3) Production challenges

Devolution is the result of a large team effort. If I look only at the development of the robots, the effort was around 44 man-months distributed over four full-time positions (circa May 2005 – March 2006): one production manager and three product designers skilled in mechanics and able to build the robots. There were also part-timers for a period of around 20 man-months. This does not count my own time, which needs to be calculated during pre-production, production and rehearsals. I evaluate my overall time as 15 man-months for this project. The first seven months of production were done in Germany where the facilities of my atelier were needed (welding, cutting, etc.). Afterwards, the production moved to Australia (where ADT is based), where the focus shifted to the final preparation of the robots and rehearsals.

One of the major constraints of such a large project involving significant human and financial resources is that once the production process starts, it is very difficult to make any major design changes. There were many moments in the rehearsal process when we discovered the potential for alternative forms and functions of the robots. Unfortunately, the time and budget forced us to discard these ideas. We could only perform minor changes or robot fixes that had no significant impact on robot behaviour but more on operability within the performance, although for the development of the prostheses I opted to develop mechanical building blocks that would only be assembled during actual rehearsals with the dancers. In this way I aimed to limit design issues, to customize the host body, and finally to optimize the exploration process with the dancers.

In parallel to the realization of *Devolution*'s machines in Germany, ADT had to develop major sections of choreography independently, without their participation. It would only be during the last two months prior to the premiere that the dancers could share the stage with the mechanical cast. During the realization phase, my atelier was constantly producing video documentation of our interim results. Stewart would then show the potentials of these different machines and he would develop a dance vocabulary that responded to that of the machine performers

	Machine performers - Atmospheric / Kinetic Stage	
The Cube		Mechanomorphic Reality-Fiction Atmospheres – Sublime
The Chorus		Mechanomorphic Body-Schema Atmospheres – Sublime .
The Swarm		Mechanomorphic Reality-Fiction Atmospheres – Sublime
	Wearable machine porformers – Integrating with the human performers	
The Prosthesis		Zoomorphic Animacy needs human body Body-Schema Reality-Fiction Atmospheres – Sublime

	Machine performers – Interacting (dancing) with human performers	
The Spine		Zoomorphic Body-Schema Reality-Fiction
The Big Bots		Mechanomorphic Body-Schema Reality-Fiction

Table 18. *Devolution's* machine performers (Demers 2006)
Permission to reproduce these images has been granted by Chris Herzfeld

4.7.4. Rehearsing with machines in Devolution

There are two major limitations that alter the immediacy of the usual rehearsal process. First there is an important safety/security protocol to respect, since the robots can potentially harm the dancers if they are wrongly manipulated. This necessary protocol imposes a rhythm that slows down the process. Second, the programming of the robots requires an amount of time that makes it impractical to execute within a rehearsal block. In sum, the rigidity of the operational framework of the robot prevents spontaneous changes, sudden explorations and improvised adaptation to errors. This situation is one of the major concerns raised by the theatre theorists Sermon and Ryngaert when they write about robots on stage (Ryngaert and Sermon 2012, p. 116).

Indeed, choreographing the movements of the robots needs exhaustive programming, which in turn generates the actuation sequences of a machine performer's muscles. This is a very time-consuming task compared with directing human performers, where you can try out variations at once. On average, I would need a few hours simply to test out a new phrase of choreographic movement. While I could save time and effort by hiring a skilled programmer, the intricate timing of actuation and proper understanding of the robot's morphological qualities made this role very difficult to delegate. Following Kaplan's observations on the animate qualities of successful embodiment, my task as a programmer was to align the control, animation and dynamic properties of the robot's morphology as far as possible.

Fortunately, building on my experience from staging numerous robot performances, I have developed working methods that alleviate some of the above concerns. First, I program a palette of nominal movements and build on these. Any programmed movement must have operational parameters such as speed and amplitude of motion that I can control live to bring variation in rehearsal. Second, I never try to program extensively during rehearsals. I simply move to another part of the performance and do the needed changes off-stage, ready for the next day. Third, to endow further variations on pre-programmed sequences (such as complex gaits), I rely on a human operator to provide additional dynamism. For instance, the Spine can build up momentum if the triggering of the actuator matches its pendulum motion. When a robot has no embodied feedback, the operator becomes an integral part of this control loop, acting as a very high level sensor (fusing predictability and understanding the end-effect of the motion). I recall Stewart noticing a less energetic Spine and asking me if I had changed anything in the program. I simply replied, there is a new operator at the desk. This architecture recalls some of the topics visited in Chapter 3 where the "intelligence" of the robot is outsourced in the operator. Another example of shared tasks between robot and operator is found with the Big Bots. They are remotely controlled by stage crews who can easily steer these huge structures on stage without dealing with the complex gait of a hexapod.

4.7.5. Public presentations and awards

Devolution was premiered at the International Adelaide Festival in 2006. In 2007, it was presented at the Sydney Festival, at the newly refurbished Carriage Works. Later on that year, *Devolution* was mounted again in Adelaide, followed by a small French tour that brought the work to world dance mecca Theatre de la Ville (Paris) and into the national stage network in Annecy. In 2008, I presented *Devolution* in the form of video screenings for the media arts festival "Mutamorphosis" (Prague, Czech Republic) and at "Art in Post-Biological Age" curated by Dimitry Bulatov (Kaliningrad, Russia). I would estimate the combined number of viewers (open rehearsals, advance-premieres and shows) of a live representation of *Devolution* is easily more than 15,000 people. *Devolution*'s YouTube trailer has a little more than 35,000 views, mostly during the piece's stage life, between 2006 and 2008. Kostas Metaxas also features *Devolution* in the art and science documentary series "A kiss of art" (S1, EP2).

The performing arts community awarded *Devolution* several prizes after its premiere, including the "Best new Australian work" and the "Best Lighting Design" at the Helpmann Awards 2006 (Australian National Performing Arts Awards and the "Outstanding Performance by a Company" at the Australian Dance Award 2006. *Devolution* also received the Ruby Award 2006 for innovation in South Australia and also several cinematographic awards for its trailers and commercials.

These awards indicate a definite level of acceptance and recognition of the value of machine performers on stage. The awards also indicate a potential to diminish Ryngaert and Sermon's concerns about the rigidity of robots both on stage and during the production process (Ryngaert and Sermon 2012, p. 116). It is important to note that this applies in the context of a full-blown production and not just in a small cameo appearance of a robot. A full-blown production implies that the machine performer has to be integrated – with all the underlying implications – at every level (pre-production, rehearsals, publicity and performances) into performance structures that usually feature only humans. With regard to McCarren's comment about the alienation and dehumanization found in early 20th century dance (McCarren 2003), I would regard the presence of *Devolution*'s machine performers on stage as a signifier of the mechanization *of* labour: the labour involved in getting this complex stage machinery in motion.

4.7.6. Analysis of Devolution's machines (perception)

This section will analyse representative robots with respect to the issues of perception and reception presented in this chapter and to the main issues raised by the thesis: i.e. the animate qualities of machine performers, the Uncanny Valley and embodiment (seen from nouvelle AI and from a broader perspective). The stage *presence* of each machine performer will be assessed with regard to the audience's perception of its animate qualities.

On the Uncanny Valley, the work presented human robotic extensions that mirror Mori's original statement about prostheses. The various embodiments found in *Devolution* stimulate discussion of their ecological and cultural bodies. So far as anthropomorphism is concerned, robotic species range from the mechanomorphic to the insect-like and finally to the human-like. The animacy analysis will look at perception of machine performers' solos, duets with the dancers, and choreographic vocabularies generated between dancers and machines. In *Devolution*, swarms, machine choruses, lighting and soundtrack, conspire to produce *atmosphere.*

1) Animacy/intentionality and anthropomorphism

In *Devolution*, morphologies span a spectrum from the mechanical to the organic. Initially all the machine performers are mechanomorphic, as they share the same materials and structural building blocks (joints). When the parts are assembled, the visual cues derived from their form determine how the audience will classify the static bodies. In static form the Cube is mechanomorphic, the Swarm, the Spine, the Big Bots and the Extensions (on the dancer's bodies) are zoomorphic, and finally the Chorus is anthropomorphic.

Bollen describes the movements of both dancers and machines:

> The envisioning of nature in these works trades Duncan's cosmic vision for the minute and microscopic. The strange ways insects move—with their crisp and crunchy biomechanics, their swiftness, swarm and buzz—are traced across the

> choreography of both works. At times in *Devolution*, Stewart's choreography recalls the movements, stranger still, of plants and protozoa. (Bollen 2006)

However, these forms have a new reading when the machines are in action. The Cube shifts to zoomorphic. The extensions become either anthropomorphic (mutualism) or mechanomorphic (extension as parasite). As the audience is progressively exposed to the machines in movement, the Chorus becomes mechanomorphic, while intentionality appears in the Swarm, the Spine and the Big Bots. The apparent seeking of motion by these machines in relation to the human performers creates these intentions. The Big Bots walk towards duets to inspect them, the Swarm circles a solo and the Spine looks at the dancing bodies from above. Bollen describes this situation:

> Unlike the dancers, these mechanical monsters have searching eyes—spotlights that transfix the dancers in their gaze. They intrude upon them and impinge upon their space. The dancers cower and sink beneath the awesome rudeness of the robots' presence. (Bollen 2006)

On the other hand, the indeterminacy of some robot behaviours is hard to classify, leaving the audience with a sensation of limbo. Bollen describes a scene with the Big Bots in its functionality, reminding me of the Heider and Simmel experimentation: "A robot drags a dancer across the stage and drops him" (Bollen 2006).

2) Embodied simulation

In *Devolution*, the mechanical extensions of the human dancer create a morphological variation on the human body (or the machine performer). Does this variation make a new body or is it still a type of human dancer? In this context Gallagher discusses issues of body-schema and perceived structure:

> The process will allow things to appear as instances of the same phenomenon until one generates a variation that turns the phenomenon into something else. To see in an essential insight, a Wesensschau, the structural invariants is to see the essence of the phenomenon and this happens when one comes to establish a horizon within which the object can vary without losing its identity as a thing of that type. (Gallagher 2012, p. 308)

By attaching a minimalistic articulated joint, the machine extension becomes a variation of the object "human dancer". Being integrated and real, it becomes a factual variation of the body. However, when the dancer is on the floor, subdued by the violent articulations of the mechanical arm, the variation is mechanical. Finally, when the dancer wears a forceful frontal extension, we are back to a variation of the human dancer. In the framework of *Devolution* and the mutualism of species, the variation is modulated on the perception of how harmful the parasite is to the host body, or how far it is in control of that body.

In turn, this variation helps to extend the body schema (the imaginative invention from our original model) and to generate the potential for triggering empathic bodily reactions. In informal discussion with performance-goers, the Tail was certainly the most favourite of all the extensions. Questions mainly revolved around the bodily perception of having this appendix in motion on your body:

- It must hurt/ Does it hurt the dancer?
- How can you dance with this on top of you?
- How does the tail interact with the body ?

4) Reality and fiction

Gallagher presents new forms of life as variations: “In addition, in probing philosophical issues that pertain to problem solving or more holistic forms of life, or ‘life as it could be’ (Langton 1989), the use of simulations and evolutionary robotics, rather than imaginative variation alone, facilitates the study of complex systems” (Gallagher 2012, p. 309). *Devolution* suggests how evolutionary robotics and new forms of body slightly alter the perceptive process described by Fischer-Lichte.

First, a new category of object is required, as Fischer-Lichte does not attribute the concept of strong presence to objects (Fischer-Lichte 2008, p. 100). I see quite a different phenomenal perception and reaction with a machine performer than with a prop on stage Likewise, where do we situate the human body – acting as a machine or subdued by the group? As Bollen observes:

> Their heads are often down, their faces turned away. Their arms curl out, a leg folds up. Sometimes they are rooted, fixed like tripods on the spot, supported on 2 knees and an elbow, 2 feet and a hand, 2 hands and a head. At other times, the dancers travel in a pack, with arms and legs entwined and overlapping. Three pairs dance a sequence mouth-to-mouth. (Bollen 2006)

Perhaps a new category of objects might be one that encompasses the mechanical robot as becoming *present* (and animate) and the animate human mass of bodies as becoming mechanical (or ecological), where the group remains as the *present* performing body. The objects in question are, in this process, transformed into vehicles of enhanced, enacted signification.

5) Atmospheres

When the Swarm approaches the solo dancer, and when the Cube performs its own solo, the intentionality of these machine performers shifts to the *atmospheric*. These machines produce an experience and a sensation to both the performer and the audience, an effect without a tangible cause.

Bollen describes the Swarm, in action with the solo dancer, in the following terms: “A man is left to dance a solo, angular and naked, but not alone […]. Waiting in the wings and suspended from the rig are Louis-Philip Demers’ robots which stumble, trundle, scatter in to survey the scene” (Bollen 2006). In this case, Bollen perceived the stumbling of this swarm as an act of observation – even surveillance – from the group. This is a bodily sensation that the audience can recall as an experience surfacing from the production of a “surveillance” atmosphere.

4.7.7. *Interview with Garry Stewart*

1) Data gathering

In late 2007 I developed an analytic survey of the perception of each different species in *Devolution*. I tried to distribute the surveys after the performance in Paris but most of the public were simply too anxious to leave the venue (Risner 2000; Glass and Stevens 2005). The few people that stayed were gathering with friends and declined to fill in a form that would have taken 10 to 15 minutes of their time. I did not want to administer the test to people who gathered in the green room after the performance as this would be a highly biased segment of the audience (dance experts). In retrospect, I should have done so, since I found years later dance perception studies that distinguish between novice and expert viewers. Moreover, the Australian Dance Theatre, despite numerous invitations, decided not to tour *Devolution* after 2007. So I had no further opportunity to administer the survey to a live performance audience.

2) Interview with Garry Stewart

To analyse the work from the perspective of the choreographer, I planned my interview with Garry Stewart around a critical review of *Devolution*. Theatre theorist Jonathan Bollen had published a paper on *Devolution* in which he investigated the translation actions and effects operating between humans and machines (Bollen 2009). Bollen also analysed the media coverage of the work.

Five years after the opening, Stewart still wished for a more elaborate vocabulary of the machines. He reflected on the effort of making all these species as opposed to concentrating on a few more sophisticated machine types. Similarly, after five years of robot development I still provided the same rationale: if we wish to offer an ecology, it has to be diversified. At the same time, this redundancy is also an analogy of nature, where species come and go and diversification blends failure and success. My other rationale is based on my experience of staging robots: as I find it difficult to maintain *presence* for a long period of time, robots can take turns to draw the attention of the audience.

Stewart sees one of the main successes of *Devolution* in its atmosphere: the sheer scale of the work, the various hierarchies of scale in the relations between human and machine performers and the energy that radiates from the stage. Bollen comments on the atmosphere:

> The robots' moves are cumbersome, and sometimes cute. When it's quiet, we can hear them creak and breathe. But when composer Darrin Verhagen's clunking, churning industrial score lends aural power to Demers' machines, we are witness to the mechanical choreography of terror. We hear bones crushing and flesh tearing. The dancers shrink in fear. (Bollen 2006)

Stewart recalls the danger of the Cube and how it felt for us to see this mass swing past dancers. Bollen describes the end of the piece, a frantic moment of activity by the Cube: as the end approaches, the stage is electrified with action, robots agitated, lights flashing, bodies pulsing. And then a screen descends. The final video is of a clustering of human flesh, shrinking, fading, and disappearing. In the curtain call for *Devolution*, as if to reassure us, only the human performers lined up for the applause (Bollen 2006).

Stewart also sees the extensions as a positive experience of altering dancers' bodies. However, he felt we did not have enough time to experiment with the integration of the artificial and mechanical into the human body. Bollen describes the extensions in the following terms: "Machines attach themselves to dancers, as parasitical appendages that pulse upon the dancers' bodies with their piston push and shove" (Bollen 2006).

4.8. Conclusion

In this chapter I have suggested that any morphology can lead to different perceptions of causality and intention, but that movement is the most highly prioritized factor in the perception of an agent's behaviour. It seems that while anthropomorphism is often an inevitable reflex for the viewer, it is very important to reconsider the pre-objectified and objectified relationship with the external agent. This is why in *Tiller Girls* I adapted a live performance from the Heider-Simmel psychological experiment on animacy, causality and attribution. However, I tried to design the Tiller Girls' movements with morphological computing methods, and attribution theory was then applied afterwards. Consequently, a wider variety of audience reactions then occurred and they invented narratives, became empathetic and shared their associations. But when agents have dissimilar bodies on stage it was more challenging to transmit social behaviours to the audience (*Devolution*). From this I would assume that the duplication of *machine performers'* behaviours causes a deeper level of identification.

Furthermore, when the correspondence problem is combined with the "shared manifold" hypothesis, the embodied simulation verifies our visceral reaction to the machine performers. My experimental results not only demonstrated that we can recognize locomotion patterns, like the Tiller Girls' point light displays, but also that we can correspond or match some of our human body schema with the original Tiller Girls' body schema. It seems that different visceral reactions have been underexplored in the performance milieu, and machine performers certainly can be used to trigger strong anthropocentric reflexes. Therefore, when the co-presence of audience and human performers is bonded, the machine performers also become more embodied.

However, the atmosphere surrounding the performer enhances all of this. Atmospheres produce an intangible yet very real presence – one that is almost palpable. Atmospheres can be effectively produced by the robotic presence on the stage and they can be designed to have an impact on the human performer and similarly on the audience's reception. *Machine performers,* especially when used in choruses or organized groups, create a genre like a psycho-plastic stage. This concept comes from 20th century scenography, and has greatly contributed to the production of atmospheres on the theatrical stage. As I have shown, my own aim was to design atmospheres for my own machine performers so as to create an experiential (visceral) situation rather than an intellectual reaction in the audience.

Conclusion

Chapters

In this thesis I have divided my research into four chapters, drawing from a wide range of transdiciplinary historical, scientific and theoretical analysis. In Chapter 1 I concluded that many similarities could be found between the experience of human bodies and machine performers. I suggested that the human potentials of adaptation and learning should be considered when building machines for performance. I also claimed that the actual morphology of the agent is not the central issue when it comes to making a machine performer credible. Perception of the machine as animate is often more a matter of the way the context and the fictitious character impact the audience – and thus a matter of the condition of the audience and the potentials of their perception. Only then can the machine performer's body in action be congruent with its fictional role.

In Chapter 2 I concluded that the discourse of the Uncanny Valley is extremely relevant for designers of *machine performers*. This is because, as a process, the artist often relies on unstable scenarios for inspiration, and the uncanny can be embraced as an aesthetic stance. For these designers, it is more relevant to look at the potentials of a machine's "presence". I would claim that the audience accepts the agent because it feels animate, rather than because of its constituent mechanics. In the Uncanny Valley, the scientific mistake is to be anthropocentric; it seems to prevent any alternative formulation of this psychological issue.

In Chapter 3, I concluded that by being machine-centric, the robots of nouvelle AI are bound to remain mechanistic objects operating in a terrain that bears no resemblance to the social terrains of human beings. Expanding the concept of robot embodiment beyond the physical environment, designers can imbue machine performers with new capabilities that the mechanistic machine does not possess. Furthering the nouvelle AI morphological computing where it distributes locomotion onto the robot's environment, the machine performers' behaviours are intangibly distributed between the audience and the machine, yet physically shared by the co-presence of both bodies.

In Chapter 4 I concluded that many mechanisms found in the various levels of human perception of movements on the stage are transferable to machine performers. Equipped with this result, when machine performers present hints of these human behaviours, audiences are better equipped to trigger these mechanisms. Those hints are the basis for sharing a phenomenal appreciation (empathy for instance) with any machine performer. Anthropomorphism and atmosphere often start with intangible perceptions rather than literal signs. What makes anthropomorphism a powerful tool for the machine performer is not a facsimile of the human body at all, but all the imagined and suggested human components around the machine performer. These suggestions are also crystallized in atmospheres; by labeling an atmosphere with a word, I suggest that the intangible becomes real.

To put it succinctly, in this dissertation I posited that my research into the "Uncanny Valley", anthropomorphism, causality and animacy can shift human perception of the relationship between modalities and the abilities of *machine performers* on the stage and in other cultural environments. I hope that by focusing with my machine performer experiments on these four areas of shifting human perception – the Uncanny Valley, anthropomorphism, causality and animacy – I will have succeeded in expanding these concepts. I will now summarize some of these expansions in relation to human perception under these same headings.

The Uncanny Valley and shifts in human perception

My original aim was to find common ground about the rejection or acceptance of *machine performers* compared to humanoids. My conclusion was that when *machine performers* are built with an aesthetic based on standard emotional levels of audience identification, then they become more popular. This result can definitely be enhanced by the use of theatrical aesthetics like lighting, dramaturgy and sound. For example, in *Devolution* the body extensions worn by the dancers produce a strong sense of audience identification with the afflicted performer. However, these extensions also play a scenographic role in transforming the human performers into a chorus of lighting devices. Unlike the shallow concept of the Uncanny Valley often used in computer scientific research, I focused on the strong and weak dissonance that comes from some representations of what I call "the quasi-living". This proved interesting for many audiences. With *La Cour des Miracles*, for instance, the dissonance signals that come from a machine performer that might be experiencing pain do not trigger an uncanny reaction, but rather an empathic response in an audience. As opposed to scientific views of the Uncanny Valley, the quasi-living status of the machine performers in *La Cour des Miracles* was not the focal point of the audience-visitors' engagement in the experience.

However, these shifts in human perception will not work without a very strong stage "presence" surrounding *machine performers.* Elaborate stage presence causes new reactions once posited by Fischer Lichte as "multi-stability perception" (Fischer-Lichte 2008). Furthermore by carefully orchestrating the (mis)alignment of *morphology and behaviour* in *machine performers,* multi-stability can be managed and even empowered. Integrating alternate morphologies into their animate behaviour can also minimize them. In this sense the machine performers of *La Cour des Miracles* and the *Tiller Girls*, as well as the body extensions of *Devolution*, are all alternative variations of morphologies from known biological structures. The combination of morphological computing and their singular bodies gives these machine performers a strong sense of presence: their representation is not specifically designed to be anthropomorphic, but their bodies can be seen as extremely animate.

Anthropomorphism and shifts in human perception

I included this topic in the thesis because it seemed essential to examine the behaviour of *machine performers* and compare them to other scientific experiments. Although I found a lot of discussion about morphological representation, this trajectory was not so popular. I concluded that a shift was needed away from the literal and scientific definitions of anthropomorphism towards an abstraction of separate parts of human behaviour that the audience can more easily identify with. Thus with *Blind Robot*, I navigate away from the complex technical task of making an anthropomorphic robot touch a visitor by relocating the experience, and thereby transforming it into an empathic relation with a blind agent. This process of abstraction seems to generate greater affinity between *the machine performer* and the audience. Certainly it tends to engender *the machine performer*'s relationship with a human when an inverted pendulum on a few springs, can make a Tiller Girl walk. The gait is decidedly abstract, but the competence of this machine performer to balance itself often mesmerizes the crowd. For this reason, in designing my performers I focused on metaphors that stage *social contexts* alongside these machines. For example, designing morphology does not provide *Tiller Girls* with high level anthropomorphism; instead, it is the historical context that gives the machine performers the connotation of a chorus line of dancers. The anthropomorphism arises from the body in action with new intentions attributed to their gestures: namely the intention to dance. Furthermore, when theatre directors combine machines with dancers from contemporary or historical perspectives this tends to attribute another role to machine performers. The point is that "a body" does not have to be anthropomorphic to behave anthropomorphically.

Causality and shifts in human perception

I realized through the practical research for my thesis that I needed to include "attribution" as part of causality, but in a different way from that taken by scientific researchers. This is because I am very interested in how the audiences judge the *machine performer*'s intentions. With the *Blind Robot* experiment, I demonstrated that given the same movement, people perceive intentions differently according to the manipulation of the machine performer's suggested character. Functionalism is also related to causality, but in this thesis I have suggested that designers take a major shift away from it and instead focus on characterization, personality and emotion. When machine performers display the loss of particular functions for the audience, then personality and characterization can be triggered. In the *Tiller Girls*, I deliberately open the performance with a series of well-behaved motions that end with a disruption caused by a "failure". So in the end the Girls plunge to the floor. This suddenly shifts these machine performers from functioning to dancing. I could sense the audience's perplexity and the triggering of dissonance. This very "failure of function" can cause a higher level of empathy in an audience. For example, when *machine performers* are built to elicit standard emotional responses from the viewer, they also reinforce this empathy. Thus the *Blind Robot*'s touch shifted from an instrumental (mechanical and functional) to an affective approach. That each viewer asks for the machine to touch him or her, in a singular and empathic sensation, means that the audience fully trusts the care and gentleness that a blind agent should possess. When *machine performers* are designed to mimic prior known affinities to motion from the historical past, like coordinated dance steps, then another type of causality takes place in the mind of the audience when they automatically make connections to traditional dance.

Animacy and shifts in human perception (related to causality)

Here my intentions were closer to theatre. The aim was to explore the potential of machine performers who move without apparent reason and in doing so affect causality. For example, if one machine performer is placed on the stage by itself, it is perceived as moving, but if two or more join in, then it becomes "dance theatre". This shift in perception seems different when viewing "real life" animation than it is when encountering abstract movements that reveal a *machine performer* with unusual intentions. Artificial intelligence researchers often seem to animate in order to understand biological behaviour, but perhaps machine performers are more inspiring if their behaviour is excitable or unpredictable. The dance-theatre director of *Devolution*, Gary Stewart, also recommended this as a theatre tactic. The point is that members of the audience always build their own individual narratives or have emotional reactions in response, because of the cultural backgrounds and experience they individually bring to the event. As Heider & Simmel demonstrated in the replication of the animacy and attribution experiment; when Tiller Girls move, their movement is perceived as walking, but when two Tiller Girls move together, it is then perceived as dancing. But group reactions also happen on the basis of shared knowledge of cultural events, so that movements from analog machines often foster historical stereotypical connotations that are very relevant for a larger part of the audience. When agency is embedded into the machine performers, they can also be seen to have causality. They could react to human movement or be extensions of human movement (*Devolution*), or react to human movement (*V5*) or simply move because they are built to play with balance (*Tiller Girls*). All of these are interesting potentials to explore when designing *machine performers.*

As I have concluded above *machine performers* are interesting new "actors" to include on the stage for a variety of perceptual reasons, however they are often made to do one thing and not be multi-functional. In this respect they differ from live actors. They do however solicit alternative reactions and dynamics, and even nostalgic longings for our own analogue past.

In this dissertation I have also compared various discussions in the realm of performance theory about the concepts of "presence" and "phenomenology". For example, the machine performer corporeality and the character portrayed "in tandem", what Fischer-Lichte once identified as a multistable level of perception (Fischer-Lichte 2008). So a machine performer can present both authenticity and immediacy to provide a richness of multistable states.

In these theories strong stage presence is mostly attributed to humans and not to objects, so I imagine that a new category could be added to this discourse about machine performers. I have claimed that machine performers can trigger primal and visceral reactions in viewers, particularly if the machines are deconstructions of the human body abstracted by the designer, in other words if they are not human but are a part of a human. Certainly, if these abstractions are dramatized for the stage, it tends to create an embodied and contextual experience for the viewer. To express this conclusion I have made a table that provides a summary outline of these concepts of presence, animacy, embodiment and atmosphere as they have been developed in successive chapters.

Practice	Presence	Agency Animate vs. Animated	Embodied Simulation	Atmospheres
La Cour des Miracles	Morphological computing. Subsumption.	Embodying pain.	T-Ing on zoomorphic machines.	Scenography of *La Cour*. Saturation of peripheral vision. Saturation of sound.
The Blind Robot	Tele-presence	Embodying a blind person vs. an instrument	Upper-Body, i.e. shoulders and waist.	Being probe.
Area V5	Gaze back at viewer.	Skulls are more automatons than bodies.	Look-gaze.	Surveillance. Sublime with scale.
The Tiller Girls	Morphological computing. Act of balance and richness of gaits given the rigid shape.	Dancing and performing bodies.	Mapping shoulder and torsos. Upward position.	Cabaret
Devolution	Extensions. Presence of swarms and chorus of machines.	Destabilization of body.	Body extensions. Spine. Cube torsions. Walkers.	Post- apocalyptic. Sublime when the Cube performs a solo.

Table 19. Overview of practice vs. chapters

This table summarizes some of the important mechanisms of perception presented in this thesis and the way each practical work subscribes to them. I hope that other researchers who are interested to explore these trajectories will analyse their own machine performers in a similar way. Therefore I will conclude this dissertation with a set of recommendations that other builders of machine performers might like to contemplate.

Recommendations for the design of *machine performers* in the future

1. Take an experimental approach to the human body

- Think about fragments of human behaviour instead of whole complex androids.
- Think about the body as an experimental variable meaning, and try to alter the morphology.
- Read about the evidence in psychology of perception to understand or appropriate how people identify with "the other".
- Be inspired by quantitative analysis of the psychology of perception.
- Don't simply build to understand the human body, but think about the body in terms of its similarities, complementarities and differences.

2. Consider the power of the stage

- Think of machines as characters, then apply the same rules for actors.
- Explore different ways to represent the environment other than the standard theatrical procedures.
- Relate body morphologies to the qualities that already work well on the theatrical stage.
- Consider the concept of atmosphere for machine performers.
- Compare and utilize scale, because the human reaction to scale creates a "sublime" emotion.
- Rather than think of a machine as being demonstrated, think about it being embodied in the installation, theatre or environment
    - Can singular or multiple characters create more dissonance through their movements, their intentions or their agency?
    - Atmosphere – use theatrical lighting, sound, etc. These are proven techniques that integrate analog machines as if they were performers' bodies.

3. Redefine Embodiment in a different way from that used by science

- Instead of thinking about how the machine interacts with the environment, think about how layers of social and cultural influences can affect the behaviour of the body.
- Try to expand the notion of body to include the imperfect, the naughty, or the surprising behaviour that adds to the identification of the body in its environment.
- Even if the machine performer can only do a few things, utilize the surrounding environment to make it look more embodied.

4. Look at Embodiment from the nouvelle AI perspective

- Approach morphological computing not as a computing problem but as a kinetic sculpture problem, nouvelle AI is imbued by this learning-by-doing.
- Empower materials.
- Ecological Balance. Concurrently design machines that have a niche in both the ecological and the cultural.
- Understand the consequence of morphologies and their intricate links with sensor-motor-control.

Perhaps other researchers and designers who are interested in building machine performers for the stage can extend this research in future.

END

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APPENDIX

List of support materials (by DVDs)

DVD 1 – *Devolution*

- Video documentation
- Full performance documentation
- Pictures
- Documentary
- Promotional clips

DVD 2 – *The Tiller Girls*

- Video documentation
- Full performance in Belgrade
- Full performance in Paris
- Pictures
- Stumpy documentation

DVD 3 – *La Cour des Miracles* / *Area V5* / *The Blind Robot*

- Video documentation of all works
- Images of all works
- Area V5 tests in laboratory
- *Blind Robot* video excerpts of subjects interacting with the robot

DVD 4 – Support Materials.

- PDF copy of this document
- Source code
- Interviews with Garry Stewart and Zaven Paré
- Publications related to the thesis
- Surveys
    - Questionnaires
    - Experimental Results
- Video clips
    - *Tiller Girls* video for Heider & Simmel experiment
    - Point light displays used in perception of motion