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Therapy-Poesis: Prosthetic Care for Damaged and Undamaged Bodies

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ABSTRACT

Finding oneself with a missing limb is, on several levels, a devastating and traumatic experience. This is compounded when treatments and the adjustment of body-part replacements are determined by stakeholders in marketing and the health insurance industry, who often adhere to technological solutionism and the objectifying clinical gaze, which detaches the syndrome from its body. This transdisciplinary project, spanning philosophy, medical design, and performance art, investigates the needs of arm prosthesis wearers and integrates the notion of 'feeling' as a novel paradigm in medical engineering. Our hypothesis is that the experience of an alien limb is aesthetic rather than functional, contrary to what is largely presumed by the healthcare industry. *Therapy-Poesis* therefore proposes an artistic laboratorial framework to better understand the psycho-physical phantoms that haunt prosthetics development, and, perhaps on a larger scale, our post-prosthetic (actual and virtual) bodies.

Keywords: experimental aesthetics, performance art, medical design, damaged bodies, prosthetics

'Experiments are purposely staged dramas, to intensify some concept, so it may be recognized.'

(Alfred N. Whitehead 1927, quoted in Langer, 1997)

INTRODUCTION

The entangling of body, mind, and technology in prosthetics (Crawford, 2014; Harrasser, 2016, 2013), the metaphor of the cyborg (Haraway, 1991), as well as discourses on dis/ability, aesthetics, and politics (The Care Collective, 2020; McArthur and Zavitsanos, 2013; Kafer, 2013; Siebers, 2010, 2011) are central to the current posthuman turn in research, education, philosophy, STS, and the arts (Braidotti, 2019, 2002). The challenge to conceptually overcome the Cartesian divide between that which thinks, *res cogitans*, and that which extends physically as body or matter, *res extensa*, has led to a larger paradigm shift towards shared humanity and care, as human singularity is being toppled, and its vulnerability is rendered explicit. The research we conducted mediates this critique with an applied artistic, philosophical and design-process-centred investigation of prosthetic hands to enhance mutual understanding between prosthesis wearers (damaged bodies) and those individuals (mostly undamaged bodies) guiding them in prosthetic care – from development and engineering to physiotherapy and orthopaedics. Furthermore, it demonstrates, on a larger scale, how the academic project of deconstructing the *Human* central to posthuman critique (Ferrando, 2012) serves as a fertile methodological ground for assessing and reassembling the fractures running through what one might call our 'post-prosthetic bodies'.

Emerging from a laboratorial framework that considers performance art and philosophical inquiry as a means for better understanding the needs of damaged and undamaged bodies, this essay collects research conducted between 2020 and 2023 with amputees, artists, and employees across the departments of prosthetics manufacturing. In 2022, we held three experimental workshops with selected participants who were recruited by the research team, which will be focused on in the following discussion.

Laid out as a transdisciplinary exploration of perception alongside the *effects* and *affect* of artificial body parts, the research project titled 'Towards an Aesthetics for Prosthetics' asked, 'Which psycho-physical phantoms haunt quantitative and qualitative research in the development of arm prosthetics?' and, 'How can they be rendered

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visible?' [1] This study of body, mind, and their possible extensions, aimed at understanding the subcutaneous, carnal rhetoric that is elemental in bridging human-machine interfaces, and followed a branch of Whiteheadian epistemological critique continued by logician and philosopher of the arts Susanne K. Langer. The experimental laboratory became the locus of an unfolding spectrum of relations and their reconfiguration.

As a feminist techno-imaginary, we proposed a *therapy-poesis* to engage the human-machine nexus and the questions above, thereby exorcising both medical engineering from the dominating clinical gaze and aesthetics from humanist ideals of bodies, to foster individual ways of sensing. In our workshops, this was achieved by augmenting empirical methodologies with performative, sensual, and disruptive elements, feeding into both the reflection of epistemological practices in the arts and the physiotherapeutic treatment of amputees. At its very base, this research hypothesises the experience of an artificial limb as aesthetic – in its original philosophical sense of *aisthêsis* as complex embodied perception – that places the concept of *feeling* at its centre of interest, furthering Langer's phenomenology of feeling in the arts (Langer, 1953; Lachmann, 2024). This is quite contrary to the normalised and deterministic framework in which utility, medical standards and cost-benefit currently shape products and treatments developed by the healthcare industry. In general, this research challenges the mechanistic approach to the body as a machine, emphasising the necessity of accounting for what bodies actually need. Various qualitative studies in this field have already focused their critique on the misguided principles of engineering and designing prostheses in terms of appeal (objective and subjective *concinnity*), [2] gain of comfort, or beyond-human abilities through biomimesis/enhancement and zoomorphic design (e.g., Sansoni et al., 2014; the company Open Bionics (2017), as well as designer Sophie de Oliveira Barata's 'Alternative Limb Project') [3] – often surpassing what has been termed the *uncanny valley* (Crawford, 2014; Mori, 2012 [1970]; Cheetham et al., 2011; Grenville, 2001) or the *uncanny simulacrum* of artificial and detached human parts (Wordsworth, 2020). The present research asks, however, what both damaged and undamaged bodies can learn from each other – not only by transcending the contours of the human body, but by engaging even more with its needs and considering its complex extended reach in design, development, and care.

This research was conducted in cooperation with the prosthetics manufacturer Ottobock Healthcare Products, since one principal investigator is linked to the company through research and development of exoprostheses. Their engagement situated the project within the industrial production process and its protagonists in development, management, and orthopaedic treatment. They facilitated access to infrastructure, materials, as well as historical and contemporary prosthesis models. Still, our activities remained an autonomous endeavour connected to the APL, the department of performance art at the University of Applied Arts, Vienna. Implementing security measures and guidelines from within the field of prosthetics development and medical engineering were paramount. The approach was continuously validated by experts in healthcare quality management.

PHANTOMOLOGY

What Haunts Medical Engineering?

Historically, in medical treatment, artificial limbs and other forms of body part replacements have been matched to the symmetry and completion of the body, enabling the social participation of traumatised and disfigured individuals. Cosmesis and prostheses of human likeness are crucial to prosthetics design in helping wearers find a way back to their previous lives after severe injury or illness (Cordella et al., 2016; Davies et al., 1970).

[1] Although resonating with a phenomenological hauntology (Derrida, 1994), this research is more concerned with examining the spectre of neoliberalism in the field of research and development of medical products and how it streamlines the process of product development. It is also directed to understanding the performance and interference of subject-object relations, thereby evoking Karen Barad's (post-)modern science critique cumulated in her philosophy of agential realism (Barad, 1998, 2007). However, this research leans more towards thinking of the posthuman turn as an interrogation of the *conditio humana* (Arendt, 1958).

[2] Sansoni et al. introduce the idea of objective and subjective *concinnity* as the perception of an overall aesthetic unity, consistency, or even harmony in design objects. This two-fold attraction is objectively defined as timelessness, universality, and class (Cf. Coates, 2003: 191), and subjectively as the perception of 'novelty,' based on subjective tastes and driven by life experience. The authors attempt an analysis of applied design principles in terms of aesthetics, and go as far as considering the process of consumer response to be determined on three levels: the aesthetic, semantic, and symbolic (Cf. Sansoni et al., 2014: 977–978).

[3] The blog post 'When Prosthetics Meet Aesthetics' (2020) published by Rich Wordsworth gives an account of the rising issue of stylishness in popular design and beyond-human functionalities in contemporary prosthetics design. His point of reference are prosthesis wearers such as Tilly Lockey, who have become 'brand ambassadors or "Bionic Heroes"' on social media, embracing the experience of growing up with artificial body parts (approx. 154,000 Instagram followers, as of February 2025). This demonstrates the increasing self-confidence and agency of individuals with visible disabilities in recent generations, a shift mirrored by the increasing pervasiveness of today's branding practices.

Figure 1. Researchers preparing for the exercise '*How to Stand Outside Yourself*' with a quality manager from the prosthetics industry. © Suchart Wannaset

Prosthetics today, and the concepts of 'beauty,' however, progress rapidly and are expanded by new possibilities of morphing and augmenting bodies and their potential – not least due to avantgardists such as ORLAN or Stelarc in the 1980s and 90s, continued today in the DIY sonocybernetic performances of musician Onyx Ashanti, [4] and even trickling into the social and pop-cultural activism of tech educators such as DJ Mother Cyborg. [5] Be it ORLAN's acts of *Self-hybridizations* (1998–2002), which considered the body as reconfigurable software, [6] or Stelarc's performance series *Amplified Body* (1986–1987), *Fractal Flesh* (1995), and *Third Hand* (developed 1980–1998), in which bodily movements were transitioned by remote promptings through the early-stage internet, the human-machine nexus has been formative for artistic explorations of the body and the possibility of technological extension. Adding its own postmodern take on the hand prosthesis as an artifact, in 2011, the medical health care company Ottobock, introduced one of its latest myoelectric hand prostheses named 'Michelangelo' after Adam's hand reaching for God's in the ceiling fresco of the Sistine Chapel – evoking quite a different idea of the agency of the arts and technology from a global company's commercial perspective.

Entering a new age of human-machine kinship with machine learning will require an ever more profound understanding of what distinguishes acting artificial systems from acting living organisms, as the messiness of life will always challenge any cybernetic ambition. [7] Prosthetic treatment is at the frontier of direct contact of human

[4] Since 1992, musician and open-source programmer Onyx Ashanti has been developing a continuously evolving gestural interface of prosthetic synthesiser controllers from custom-fabricated plastic and electronic parts. His performances join electronic sound with bodily motion and resonate with Afrofuturism, post-digital media art, as well as electronic music influences from French avant-gardes of the 1970s and early 1980s.

[5] Mother Cyborg, the artistic moniker of Diana Nucera (Nucera, 2019), is an activist in the field of community education. Her main concern is to popularise knowledge of the newest forms of technologies and media. This work caters to socially and economically empowering children and youth of lower-income communities in Detroit. In 2018, she published the book *A People's Guide to AI* (Nucera and Onuoha, 2018).

[6] ORLAN announces her manifesto of carnal art (*Manifeste de l'art charnel*) with one of her first public cosmetic surgery performances, asking, 'Ceci est mon corps? Ceci est mon logiciel?', May 30, 1990 (LouisBarron, 2013).

[7] A research team at the Institute of Automation, Chinese Academy of Sciences, led by Prof. Yi Zeng, Founding Director of the independent Centre for Long-term Artificial Intelligence, demonstrated how robots can experience the rubber hand illusion by developing a brain-inspired computational model that autonomously constructs bodily self-perception. The study validated their findings through experiments using an iCub humanoid robot. This research exemplifies the cross-pollination

flesh and organic movement with non-organic materials and systems, making it a site of new development that embraces the latest technologies, such as integrating artificial neural networks in prosthetics to close the gap between the mechanics of myoelectric devices (Greek. *mȳs* [gen.: *myós*] prefix for *muscle*) [8] and the embodied movements of their wearers (see most recent report on AI integration at Ottobock, Rogy, 2023). We, however, propose that 'feeling' be considered an essential paradigm in health care design and medical engineering, as it illuminates the blind spots often present in assessments of bodies and their needs. Our critique concerns the technological and economic abstractions with which prosthetic aids for human bodies are currently evaluated and scaled. Standard medical design ignores the aesthetics of prosthetics, meaning the perceptual appeal of integrating an artificial limb in movement and body-feeling, thereby categorising the actual experience of amputees – in a philosophical sense – as 'pathological,' invaluable or untrustworthy. However, these many unrecorded aspects strongly influence the therapeutic success and follow-up care of amputees. In fact, problems on this level often cause prosthesis wearers to abandon the aid, deeming the expensive treatment almost useless. While the real numbers of rejected prostheses still lie in the dark, health insurance and reimbursement companies respond to orthopaedic reports on this phenomenon by restricting treatment with expensive electronic prostheses and making access dependent on age, gender, or even profession, and ultimately social status. Not to mention psychological counselling barely being addressed in post-amputation treatment, or the exclusion of underrepresented groups such as females or amputees with special concerns, e.g., to colour-match their skin tone, or facilitate enough robustness when handling, e.g., a baby. This selective attention obeys market rules, ignoring the literal phantoms that haunt medical engineering and the assessment of personalised healthcare products. We believe that not enough effort is being put into understanding why so many wearers abandon their prosthesis. Our assumptions are confirmed in several conversations with representatives from physiotherapy, orthopaedics, and from amputees themselves, who lack methods to tackle and convey these serious concerns when handling their own prosthesis. It seems there is a great demand for co-creating processes that can benefit the research and involvement of amputees' actual needs.

Therefore, our objective was to develop therapeutic models and exercises that reveal the unpleasant, painful, and embarrassing problems that rarely come up in the standardised processes of the industry. We designed experiments between art and science, utilising the laboratory's theatrical effects to elicit and elucidate the specialised knowledge of prosthesis wearers and intuitions of non-accustomed users that would otherwise remain in the dark. We performed 'phantoms of the lab' as those moments of error, awkwardness, fragility and despair with participants in staged settings to expose the epistemological gaps in medical engineering's understanding of the lived experience with health care products, and capturing how bodies actually *feel*. Within this context, we defined 'feeling' as the intimate and ongoing process of adapting to an altered body image, a process often traceable in the participants' posture and compensatory movements.

Performative protocols were implemented in workshops specially designed for the members of research and development, orthopaedics and quality management working at the very interface of technology and human physiology. Some participants were, in fact, part of the above-mentioned departments working on the development of systems linking cognitive motor skills with artificial neural networks for automated pattern recognition. Within the laboratorial environment, they engaged in appropriated neurophysiological experiments that encouraged reflection on mind, body, and the meaning of technology through performing movements and gestures. We recast the relations of observer and observed, researcher and object of research. This enabled an experiential workshop where participants could investigate their own body sensations and body image – including their internal representation of their bodies, known as the *homunculus* [9] – with and without artificial limbs. Sessions involved

of neuroscientific research on proprioception and robotics, enabling machines to develop kinaesthetic capabilities similar to those found in biological systems (Zhao et al., 2023).

[8] Myoelectric (or bionic) prostheses, representing the state-of-the-art in prosthetics development, are controlled by muscle contractions. This technology converts signal patterns of body movement into control signals for an electric prosthesis. Most models use electrodes connected to the skin of the stump, recording the smallest electric currents. The newest surgical research in this field goes towards directly intercepting nerve tracts leading to the limb, wiring the control centre of the electric prosthesis to the brain's anatomically extended reach. Both techniques enable a more natural and fluent movement. The latter procedure, however, relies greatly on the intactness of remaining limb-muscles, as well as the integrity of nervous tissue, and, ultimately, the acceptance of the alien prosthetic components.

[9] Building on Wilder Penfield's term '*homunculus*' (Penfield and Boldrey, 1937), which conceptualises the topography of body parts represented in the sensory and motor cortices of every mammal, we explored the impact of prosthetic use on both the neural representation of the body and individuals' sense of their 'virtual body', or body image. Derived from Penfield's systematic mapping during brain surgery on fully conscious patients, the *homunculu*s (Lat. 'little person', 'little [hu]man') presents the varying and overlapping of neural correlates of body regions and their functional arrangement in the brain. The persistent cortical representation of the missing limb plays a great role in the phantom pain of amputees. Our research investigated how prosthetic experience modulates this neural representation and shapes individuals' sense of their body image

prosthesis wearers and individuals with no impairments. The groups were heterogeneously composed of members from the prosthetics industry, artists, as well as art, performance, and design students.

The newest evolutions in prosthetics cater primarily to the idea of mind-controlled prosthetic arms that promote technological cyborg phantasies by interlinking the human with the machine. This reaches as far as surgical procedures on amputees' split nerves, reconnecting them to muscle groups that facilitate the necessary contractions for electrodes to transmit signals to a myoelectric prosthesis (Bergmeister et al., 2021). While medicine and technology move ever closer to the brain and its extension in the nervous system, amputees' bodies are being subordinated (abstracted) to a modernist ideal of the machine. This recourse might originate in the prosthetics industry's own roots in the devastating war machines of the first half of the twentieth century, injuring thousands, and industrialisation's great appetite for human resources, tethered to production machines running at full capacity (Harrasser, 2016: 100–124). Contrary to this prevailing appeal of the mechanised human, and its transhumanist chimera in the medically augmented cyborg (Clynes and Kline, 1960), the method of *Therapy Poesis*, as applied in our workshops, explores alternative perspectives to the technophilia that informs the field of prosthetics (Näder, 2019). Following the currency of new feminist techno-imaginaries, we propose the integration of a 'therapeutic poetics' to prosthetic research as a technique to reveal and involve human bodily needs in technology, thereby softly exorcising the industry from its fetish. We intended to humanise the machine.

Driven by artistic curiosity and adventurousness, we applied a certain epistemic disobedience to the field of medical product engineering, whose empirical methods and standardised product development processes serve as an intriguing field of investigation for those seeking to understand and unearth the subtle rhetoric(s) of our physical and virtual bodies. The parameter of sensory and emotional feeling, buzzing allusively in this research, serves not only as the interface for embodied experiences with artificial limbs, but is itself connected to a theory of embodied mind that offers a toolkit for reaching further into proto-conceptual territory and unlocking yet undetected phenomena through artistic research. We consider 'feeling' through the lens of analytic philosopher of the arts and of proto-linguistic mental substrata, Susanne K. Langer (1895–1985). She offers a theory of perception for conceptualising the epistemological import of artistic expressiveness (Langer, 1953) that we found performed by the participants in our experimental settings. Hypothesising art as presentational form (Langer, 1993: 79–102) – meaning-making free from questions about purpose, functionality, or market significance – gave us insight into the otherwise obscured and subcutaneous reach of the *effects* and *affect* in participants with artificial body parts. The exercises performed by the participants became instances of insight into the phenomena that stand in the way of an even more user-friendly orientation of prosthetics research and development. As artist-researchers, we enacted a reordering of relations that facilitated uncommon forms of intersubjective experience between participants.

Within a series of workshops titled *Phantom Lab* conducted in 2022, our group appropriated neurophysiological experiments such as *How to Stand Outside Oneself* (Altschuler and Ramachandran, 2007) or the *Rubber Hand Illusion* (Holmes et al., 2006; Botvinick and Cohen, 1998), turning laboratorial settings into performative ones. Participants from the prosthetics industry, as well as amputees, artists, and art students, comprised heterogeneous groups and underwent experiments on their physical and phantom bodies while under a pseudo-medical gaze. [10] The appropriated experiments were conducted in a closed space to maintain a sense of intimacy and focus. The participants' perspectives of observer and observed sequentially interchanged.

The Phantom Lab

The field of neuroscience has developed a fascination for phantom limb phenomena, aiding in understanding the effects of amputation on the human motor-sensory cortex and providing insight into how the body and mechanical prostheses interact (Brugger, 2004). The concept of a 'virtual body-mind', which we define as the user's integrated sense of their body (incorporating a prosthesis, encompassing proprioception, kinaesthesia, and body image), offers insights into the embodied mind and various connected psycho-physical phenomena (Ramachandran et al., 1995; Ramachandran and Blakeslee, 1998). While neurophysiological experiments have

in what we term 'virtual body-mind'. Simple techniques applying two picks of varying lengths to measure the sensitivity of body regions enable the mapping of the homunculus without surgery (Corlew and Walker, 2015).

[10] The groups were comprised as follows: four participants in Group A: one prosthesis wearer professionally active (unrelated to the health care industry or art world), one Senior Researcher in experimental artistic design and Medical Humanities, one artist concerned with prosthetics (Alumni), one curatorial assistant (Alumni); Group B: five art students participating in a project-related lecture; six participants in Group C: one Quality Manager from the prosthetics manufacturer Ottobock, one Physiotherapist working in Research and Development at Ottobock, one amputee working as an Electrical Engineer at Ottobock, one Professor of Fine Arts, one artist concerned with prosthetics (second participation), one Senior Researcher of experimental artistic design and Medical Humanities (second participation). Macro-analysis of groups was not conducted, as our interest focussed on the participants' individual experience, which was recorded in questionnaires. There were thirteen participants in total, two participated in the workshops twice (control members). In post-amputation therapy, re-traumatisation and physical injury are serious concerns. Participating amputees were briefed and asked for consent.

become common exercises in the treatment of amputees (e.g., sagittal mirror exercises alleviating phantom pain and facilitating the integration of artificial limbs in body movement), the discourses that address the marginalisation of bodies and questions of how damaged and traumatised bodies accept their prostheses only gradually trickle down to medical engineering. Hence, we reverted to *phantomology*, a term we take from Stanislav Lem's *Summa Technologiae* 1964, referenced in Brugger, 2004 to designate the possible modification of the virtual body-mind, in connection with an artistic and performative investigation of how prostheses change posture and movement. *Phantomology,* understood as a state in which the physical and psychological conjoin, introduces a level of interaction benefiting and training the interpersonal understanding of amputees, carers, physicians, and respective stakeholders in the production process of prosthetic devices. We hereby proposed a kind of artistic practice that seeks to fuse with medical research, questioning and evolving the empirical study of the body mapped in the brain with artistic inquiry. We find connecting points in artist Alexa Wright's scientifically significant artistic research on the subjective experience of phantom limbs in *After Image* (1997), which influenced medical studies on the brain's hardwiring in neuropsychology (Halligan et al., 1999).

Our research within the *Phantom Lab* picks up the understanding of the virtual body-mind, aiming not to treat the prosthesis wearers but the medical engineers, technical designers, and orthopaedists involved in the treatment process. We scripted and implemented performative protocols, staging therapeutic exercises with an openness to improvisation that allowed us to trace the psycho-physical phantoms running beneath the radar of statistics and functional analysis in the development and treatment processes. [11] Conceiving of the *Phantom Lab* experiments as purposely staged dramas, we flipped perspectives, making those who usually study prosthesis wearers the ones under observation and introducing instances that elucidated the observer's effect on the observed, but also expanding what affects the observer's perception.

The framework we gave was structurally and aesthetically very similar to a clinical setting. Participants were asked to stay in a waiting area where they had to patiently remain until they were called up. This already shone a light on the raw hierarchical gradient of the medical gaze. Participants could hear but not see what awaited them. The principal researchers acted as if they were in preparation for the forthcoming sessions, ignoring the participants' presence. The waiting time was artificially expanded, pushing their endurance. Not realising that they had already entered Part I, which was designed to explore the relational and hierarchical aspects of the medical field, the full course of experiments would unfold in four phases: I. Relational Aspects (the waiting room); II. Lab Experiments (appropriated and modified neuroscientific exercises); III. Self-exploration Exercises with Prostheses; and IV. Skilfulness Tests with a Prosthesis.

The Rubber Hand Illusion (**Figure 2** and **Figure 3**) (Holmes et al., 2006; Botvinick and Cohen, 1998) of Part II illustrates how proprioception, projectivity, and sensual stimulation are hardwired in the human brain. Seated at an empty table, centred with a visual barrier at about eye-level, participants were asked to hide one hand behind the visual barrier. This hand was replaced within view with an artificial equivalent (in the present case, we employed a latex glove in a light skin tone used to coat a prosthesis). The body was covered by a sheet, visually integrating the alternative body part into the participant's body schema. On each side of the visual barrier, the instructor stroked both, the actual and the artificial hand with a brush, forming a connection between this movement and the sensation on the participant's skin. The instructor occasionally omitted strokes on the actual hand, providing only the visual stimulus without its physical backup. A majority of participants still felt the stroke when seeing the brush touch the artificial hand. [12] The experiment ended for all participants with a dare they were not prepared for: would they pull back their real hand when a hammer suddenly hit their false rubber hand? Again, the majority of participants showed a very alert reaction to this event.

The second phase of *The Rubber Hand Illusion*, expanding the original neuroscientific experiment, involved each previous participant as a bystander. They observed the same procedure on their colleagues twice more, viewing the scene from its theatrical side with the rubber hand on the table, yet with perfect knowledge of the actual hand being behind the scenes and understanding when the final element of surprise would set in. What interested us here was whether viewing the scene would be perceived more intensely than experiencing it, especially the sudden disruptive act of hitting the rubber hand with a hammer. Indeed, an overwhelming majority of participants had an even stronger reaction when observing the scene. This effect was surprising even to the participants.

[11] The selected experiments, their format and how they were concatenated were probed in a test-run with students of performance art in a workshop at the Angewandte Performance Lab (APL) in 2021. See https://phantom-lab.uni-ak.ac.at/index.php/2021/09/24/phantom-lab/.

[12] Thirteen participants partook in the experiments, twelve were subsequently interviewed. Seven out of twelve reported feeling the 'phantom strokes' on their hand. Four of the remaining group who did not feel the strokes identify as artists. One is a prosthesis wearer. An indirect finding within this experiment indicates a differentiated susceptibility to deception in artists. This became apparent when reviewing qualitative questionnaires documenting the participants' experiences throughout the course.

Figure 2. Lab Experiment Part II: Conducting the 'Rubber Hand Illusion' with a prosthesis wearer (the participant is an electrical engineer working in prosthetics development). © Suchart Wannaset

Figure 3. Lab Experiment Part II: The 'Rubber Hand Illusion' conducted with participants based in the arts and medical humanities. © Suchart Wannaset

Figures 4, 5, 6. Lab Experiment Part III, Self-exploration Exercise: *'How to Stand Outside Yourself'*. Participants (students) reflect their 'disfigured' self in the mirror cabinet. © Suchart Wannaset

The intensity of their reaction varied depending on the level of disclosure of the 'trick's' mechanisms, yet the affective moment prevailed.

Part III. Self-exploration exercises made use of the great deceptive nature of the embodied mind. We titled this experiment *How to Stand Outside Yourself* (referencing Altschuler and Ramachandran, 2007). We were able to let individuals without prostheses leave their familiar perception of being in their body. They experienced the loss of body parts and the addition of new artificial limbs. Here, participants were guided into a mirror cabinet with two full-length mirrors set up in parallel across from each other. This elementary but effective exercise in neuropsychology was originally designed to study how, when perceiving the corporeal self, vision, touch, and the body's sense of proprioception are joined. Furthermore, in neuropsychology, it elucidates healthy and diseased states like Mirror Agnosia or Alice in Wonderland Syndrome. [13] In amputees, exercises of this sort are used to ease phantom pain and treat the curious phenomena of dissociated body morphology often occurring when a body part had to be amputated. [14]

Participants were asked to enter the mirror cabinet, to focus on the third reflection of themselves in the chain of infinite mirror images, and to touch their limbs or face, which caused a feeling of dissociation between their touch and the visual body – an alienating experience. This feeling formed the basis for further self-exploration and self-modification, led by an instructor who asked participants to hide one arm under their shirt or a sheet. Then, they were asked to find a way back to seeing and feeling their body in the mirror. Similar to a fitting procedure at a tailor's shop, the instructor then pinned a rubber arm to the participant's shoulder, giving them time to familiarise themselves with the new uncannily passive limb. This procedure was repeated, sometimes leading to quite absurd multiplications of limbs (**Figure 7**). Colleagues viewed the scene as bystanders and were then invited to join in or interact by introducing objects or themselves. This exercise was conducted with amputees and individuals without impairment.

[13] Mirror Agnosia describes the phenomenon of individuals lacking the ability to recognise themselves in a mirror, or stroke patients suffering parietal lesions who cannot distinguish objects in three-dimensional space from their reflection in a mirror when perceiving them on the intact side of their visual field (Ramachandran et al., 1997). Alice in Wonderland Syndrome, in turn, describes the phenomenon of individuals perceiving their own body or outside objects as smaller or larger than they are. The syndrome can also affect other senses such as hearing, and is related to head trauma, migraine, or virus infections like encephalitis or Epstein-Barr virus (Blom, 2016).

[14] Neuroscientist Vilayanur S. Ramachandran contributed to the popularisation of neuroscience and the study of phantom limb phenomena. His 1998 publication, *Phantoms in the Brain*, explores the complex sensory changes that occur after amputation, as the neural representation of the body (*homunculus*) adapts to the altered physical reality. His meticulous engagement with patient reports on phantom-body experiences gave way to a more profound understanding of the architecture of the brain and the mind-body axis, demonstrating how, in the morphological development of an organism, neural hardwiring can diverge from the idealised image of the body. One example describes the unusual shift of sexual arousal due to the overlapping and proximity of the areas mapping the leg (or ear) to the genitalia (Ramachandran and Blakeslee, 1998: 21–38).

Figure 7. Lab Experiment Part III, Self-exploration Exercise: 'How to Stand Outside Yourself'. An orthopaedist (left) and a prosthetics R&D engineer (wearer of prosthetic arm) (right) interact with modified limbs. © Suchart Wannaset

The aim of this experiment was to examine how participants act when confronted with their modified appearance in a mirror. Finding themselves now at the centre of attention, we simulated the objectification and pathologisation inherent in the medical gaze. Placing participants in this position of being observed and analysed, allowed us to explore the contrast between the external, clinical perspective and the profoundly personal experience of living with a prosthesis. More than altering their appearance by tying off the arm and visually changing the participant's able body, the additional perceptual layer of dissociating from the body carried over from the previous exercise (causing participants to 'stand outside' their body) led to a realisation of how amputees are compelled to overcome fear and block emotions when familiarising with their altered corporeal self. Prosthesis wearers, having gone through several psychological stages of processing, and having learnt to grasp the modifications of their bodies, were quicker accustomed to the play and interaction with additional body parts as well as the observation and scrutiny of others. This exercise challenged deep-seated societal ideals in the construction of body and beauty, prompting questions of ability and disability, and the limitations of quantitative medical evaluation.

Figure 8. Lab Experiment, Part IV: Skilfulness Tests (drawing exercises). An amputee uses their prosthetic hand for drawing. © Suchart Wannaset

Figure 9. Lab Experiment, Part IV: Skilfulness Tests (drawing exercises). A quality manager in the prosthetics industry writes a name using a prosthetic device designed for self-testing by developers. The prosthesis is steered with a joystick (hidden here under the table). © Suchart Wannaset

Figure 10. Lab Experiment, Part IV: Skilfulness Tests (drawing exercises). A student transcending the limits and norms of the body and drawing. © Suchart Wannaset

Part IV in the course of experiments involved the participant's skilfulness in adapting to a hand prosthesis. Here, we conducted elementary sensorimotor exercises testing aspects of balance, comfort, and usability when holding or moving an object – those movements that literally *matter* in the daily lives of amputees. Non-impaired participants were asked to restrain their motor capabilities by either binding their arms and hands or replacing the hand with a self-experience prosthesis, an electric device often used by engineers and orthopaedists to test-drive prosthesis during manufacturing and fitting (see **Figure 9**). [15] The task was to complete a series of drawing exercises with their newly disfigured body, which not only limited their movement, but whose rigid materials sometimes cut and pinched the flesh. Notably, there was more attention to detail in the drawings of the amputees, which highlights the anatomical aspects in drawing, where movement is primarily steered by the shoulder and upper body, and least by the wrist. Even with a static hand prosthesis, which is not intricate enough to mimic an actual hand's fine motor skills, the drawing results from hand prosthesis wearers were significantly better than those of their disfigured able-bodied colleagues (often artists). Gesture and line are led by movement of the whole body, which is more pronounced in amputees, who exercise frequently to compensate for the lack of a limb. Awareness and control of posture are therefore higher in amputees, who train the body to carry and integrate elements related to their weight, the range of motion, and flow of body movement they allow. Prosthesis wearers remarked that they had to face numerous setbacks during the process of fitting and adjusting to their prosthesis and were quite proud to observe how their efforts showed up in this experiment as they outperformed their able-bodied colleagues.

THERAPY POESIS

This research combined elements of artistic playfulness and improvisation with a methodological structure. While it developed experiments from scientific approaches and conjured the *phantom lab* from neuropsychology's fascination with phantom limb phenomena and the brain-body connection, it made sure to keep an openness to the unexpected in the performative protocols that were implemented. Moreover, we introduced intermediate

[15] A self-experience prosthesis, or a prototype testing shaft, allows developers to attach an electrically driven myoelectric hand to their arm and steer its movement with a joystick. It functions similarly to Stelarc's construction of the 'Third Hand' (Stelarc, 1980). The device is custom-built for testing purposes during production.

sessions of physical exercises and relaxation that catered to the awareness of tensions and resolutions in the body (see **Figure 1**). Our aim of catering to a politics of care by subversively altering the mechanisms of medical assessment lent time and space for participants to engage with their own blind spots regarding concepts of normalcy and self-perception, the role of the observer and observed as well as the plasticity of the body schema. For the first time, employees working in prosthetics manufacturing, who usually affect the clinical gaze, were able to leave aside this kind of objectification (as well as the result-and-revenue-driven policies of corporate governance) and focus on reflecting about a newly acquired situated knowledge (Haraway, 1988: 583). The notion of alternating perspectives of observer and observed gives way to understanding how the spectrum of sensory data as *receptacles of meaning* comes about (Langer, 1993: 90). Participants were offered the opportunity to evolve in – and to resort to – an embodied knowledge, which is rarely elicited in the day-to-day business of the company. Highlighting the ambiguity of taking the place of the 'subjugated' (Haraway, 1988: 583–4) – especially in the presence of the clinical gaze – the experience of discovering their own body, its awkwardness and vulnerability, together with amputees introduced a reordering of relations beyond emphasising a perspective of affective involvement. With the theatrically augmented empiricism implemented through the experimental set-up, we created a middle ground, which extrapolated from experience without being formalistically bound to it. This recast objectivity as a democratic and inclusive practice with various vantage points (cf. Braidotti, 2019: 135–137). The *Phantom Lab* offered a place to leave behind disciplinary conventions, to (re)constructively engage with the 'other' in odd hunches, suspicions, or simply in the pleasure of weird experiences with one's own phantom limb. The pseudo-medical setting was a place for shared *feeling* and a way to reintroduce the *pathological* in the handling of body image, thereby exorcising an industrially standardised aesthetics, which still governs the principles of prosthetics design (Sansoni et al., 2014).

The pathological is drawn upon in this research in two ways: 1) its use in ancient Greek rhetoric as *pathos* (*πάθος*, 'arousal,' 'experience,' 'feeling,' 'something that occurs in one'); as a kind of carnal rhetoric that joins aesthetics, medicine and ethics, and that has meandered through Baumgarten's *pathologia aesthetica* (1739) (Kliche, 2000) to a (post-)post-structuralist theory of affect (Massumi, 2002), and 2) its modern clinical use – to distinguish the deviant from the 'normal.' The pathological behind the medical curtains of the (pseudo)laboratorial set-up in the *Phantom Lab* became an opportunity to experience limb-loss and anomalous conditions of body modification. Framed as an artistic experience, we utilised the ability of the viewer to meet with the participants' experience *halfway* (Langer, 1953: 393) and to inject an alternative subcutaneous *logic of feeling*, of cognitive and sensual aspects of perception. The emphasis on the pathological in this context joined the quest to imagine new design principles that consider the novelty and complexity of differing bodies and body-minds, and to expand our standardised notion of beauty to be inclusive of individual needs.

Medical engineering is largely influenced by rather normative taxonomies of the human body (gender, size, race, general practical features) that lead to normative product lines. The performative protocols implemented in our research allowed new questions to arise such as, 'What does it actually mean to experience a missing limb?'; 'Is this feeling shared by damaged and undamaged bodies alike?'; 'How does the body-mind adapt to artificial body parts?'; 'Is there such a thing as *un-feeling* the body?'; 'How do proprioception and body image change over time?'; and 'Is this the case for both damaged and undamaged bodies?' By addressing these questions, and at the same time scrutinising the certainties held by the medical health care sector regarding bodies, we became aware of the fact that more personal approaches to coping with limb-loss and reintegration are needed. This highlighted the importance of a qualitative dimension of time rarely considered in the quantified sphere of industrially scaled health care.

In terms of poetics, *Phantom Lab* positioned amputees and artists as co-protagonists in the performative staging of experiments. This freed members of the prosthetics industry from their strictly medical perspective and its predetermined notions about the purpose and function of prostheses. All joined in an obscure and theatrical blend of 'clinical laboratory and artist's studio' to expand the experience with prostheses and improve their methods of production and assessment. Self-experience exercises with prostheses revealed the lack of substantial exchange between the medical engineering field and prosthesis wearers. The exercises were able to evoke, in members of prosthetics development, a feeling for, and direct understanding of, what it means to wear a prosthetic arm, as well as the disturbing incision of limb loss. These insights, in fact, led to the implementation of more inclusive and user-oriented design processes in the company. Teams at Ottobock have since introduced changes regarding the integration of co-creative strategies in research and development – they are modifying qualitative and expanding quantitative methods by designing interactive test sessions with prosthesis wearers. [16]

[16] This information was reported back from an employee of Ottobock who has taken up insights from the workshop for their profession. In particular, variations of self-exploration exercises with various prostheses have made it into the movement laboratories of physiotherapists. These additional exercises were then instigated by employees working in development and design wanting to understand the psychological aspects of new shapes, materials or mechanical parts.

Experiencing one's own body-mind phantoms in the performative staging and dramaturgy generated an awareness – both in the context of research and development of prostheses and in the arts – of how the effects of representationalism (one's own attitude and preconceptions) can lead to distortions in assessing and interpreting data, especially in the scientific realm. Figuratively speaking, reaching for the subcutaneous phantoms enabled us to alter the principles with which design processes in prosthetics unwittingly suppress the needs of the vulnerable bodies they treat. Many areas in medical research are still restricted by the questions they can ask, and the resulting knowledge their experiments will answer. Yet, the playful poetics and theatricality of *Phantom Lab* allowed for aspects beyond the formal structures of language and the discursive symbolism of science to be engaged. It elucidated an additional order of realism that informs the daily life and acceptance of prostheses on a psychophysical level.

Artistically (particularly concerning performance art), interacting with the contours of damaged bodies enhanced our knowledge about how intersubjectivity occurs, also generating questions of where to position the agency of non-human entities like AI, currently bound to become servo-systems managing the gap between machine code processing, interpreting, and predicting patterns in body movement. *Phantom Lab* manifested the invisible complexity of body, mind, and technology in movement as a *poesis* of matter and mind. This research sought to review the contours of humanity, while at the same time exploring our misjudgements regarding the representation of the human.

CONCLUSION

Situated between the arts and medical care, we raised attention in medical engineering to the vulnerability of bodies by including the pathological and questioning the foundations upon which aesthetics itself, as a theory of feeling, is based. We explored the limits of aesthetics by asking how much further a damaged body can feel, and whether the medically imposed experience to un-feel one's phantom body after amputation can be shared by undamaged bodies. Experiments on the shared experience of a virtual body-mind; out-of-body experiences in the mirror cabinet; self-perception with third (and fourth) arms; and the actual replacement of a functional limb with prosthetic elements challenged protagonists from the prosthetics industry to engage with uncomfortable questions and to acknowledge their bias regarding their notion of bodies. General assumptions about the necessity of personal engagement change greatly; questions of dependence and care arise, as well as insights on the mattering of mistakes in the construction of a prosthetic body.

Our research showed how both unimpaired participants and prosthesis wearers can easily alter and change the 'natural' feeling of their individual bodies and integrate artificial body extensions (anthropomorphic and alien). These exercises in experiencing the 'other' for oneself cater to the development and training of interpersonal understanding in medical treatment. The objectifying clinical gaze is suspended and enriched by instances in which the formal structures of clinical research and the development of standardised medical products are critically reviewed.

By uniting artistic research with philosophy and design, our interdisciplinary approach enabled a common ground to emerge between different systems and ways of rendering the 'real'. Appropriating empirical methods in the field of the arts offers intriguing loopholes for artistic and philosophic inquiry by handing agency over to newly formulated abstractions. Heterogeneously formulated, these abstractions drew not only on neuroscience's focus on neuroplasticity and medical design's concern with technological solutions but also on the philosophical framework of Susanne K. Langer, whose theory of feeling and embodied symbolisation allowed us to capture the complex interplay between the prosthesis, the brain, and the user's sense of self. *Phantom Lab* provided a space to act within a proto-reality that hypothesised new symbolic values and offered a playing field for the co-creation of processes in research and development.

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