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Redressing perspectives: Mediation, embodiment, and materiality in digital fashion and smart textiles

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Introduction

While the shift from mechanical to digital textile technologies has led to new systems of manufacturing and distribution such as 'on demand' production, new hybrid forms of textile and digital technologies have given rise to distinctive new mediums including smart

textiles and digital fashion. These areas overlap with the field of wearable technologies and are collectively referred to as 'soft wearable technologies'.[1] [#_edn1] With a focus on military, safety, health, and sports applications for bio-monitoring, environmental sensing, and performance feedback, research in these fields has been concerned with technical functions framed within a discourse of science and computing. However, computing is not just a rational science, it is a philosophical enterprise in the way it represents the world and supports particular models of reality, people, and action. The implicit dualism of hardware and software that is fundamental to the origins of computers as calculating and business machines parallels dichotomies of body and mind, materiality and abstraction, that underpin the cognitive science frameworks that influenced computer science.

The development of soft wearable technologies has drawn expertise and methods from a number of disciplinary domains. This 'hybridisation of dress and device' raises a number of theoretical issues that demand broader consideration.[2] [#_edn2] The nexus of technological, physiological, material, and cultural perspectives that underpin the field introduce different dimensions and the potential for a new ontological positioning. The development of 'wearable, washable, drape-able computers' as a new type of embodied 'flexi-ware' raises questions about the dualistic assumptions of ubiquitous computing and human computer interaction design (HCI) that have underpinned developments in the field of wearable technologies to date.[3] [#_edn3] Given the embodied dimension of these new

mediated forms, it is curious that the fields of fashion and dress theory, and of media studies, have been slow to engage with the emerging discourse of soft wearable technologies.

Commercial wearable technology applications have tended towards gadgets, monitoring, and self-quantification. Understanding the full potential of this new medium requires a deeper consideration of theoretical and methodological frameworks and creative experimentation to inform reflective approaches on relevant areas of application. Three practice-based, smart fashion and textiles projects conducted by postgraduate students at Auckland University of Technology are discussed here in relation to concepts of mediation, embodiment, and materiality, dawn from areas including fashion and media theory, contemporary aesthetics, embodied cognition, and new materialism. The projects, by Amit Gupta (Emotion Sensing Textiles, 2013-2015), Caroline Stephens (Digital Dynamics: An Interactive Design Process for Generating Knitted Textiles, 2015-2016), and Miranda Smitheram (The Hand of the Cloth: An Ontological and Aesthetic Unfolding through Digital and Virtual Materiality, 2014-2016), engage with textiles, bodies, and new technologies, with each project having a distinctive orientation, process, and outcomes that include conceptual and methodological tools with design implications. The focus on mediation and the embodied and physical dimensions of soft wearable technologies is emphasised through a consideration of garments and textiles as the mediating surfaces between our bodies and our environments.

This entanglement of material object and subject informs new methods of fashion and textile design and new understandings that challenge dualities of material and immaterial, exterior and interior, body and mind, object and subject as part of an ontological reorientation of the human as part-of, rather than apart-from, the world.

Fashion, dress, and theory

The distinction between the terms 'fashion' and 'dress' has been described as the difference between 'industry and street'.[4] [#_edn4] There is an overlap between these fields, however. Both are concerned with clothing, be it in the context of an industry engaged in expression, desirability, and consumption, or in relation to the study of what people wear now or in the past. Despite a longstanding engagement with clothing the human body, the areas of dress and fashion have been ignored in the emerging discourse of wearable technologies. Susan Ryan recognises this oversight, demanding that 'the messiness of dress must be reconciled with the systematic programming of devices that seek affective returns' if the development of smart fashion is to become 'a more critical, transversal practice'.[5] [#_edn5]

This exclusion echoes the historical omission of fashion and dress from serious academic discourse, a neglect attributed to a cultural prejudice against the frivolity of fashion and its status as part of a commodity system. The mundanity of dress and its 'feminine' nature, associated with the intimate relationship between body and clothing, also influenced its

slow acceptance as a serious area of academic inquiry. Theories of fashion and dress that emerged in the later part of the 20th century focused on the fashion industry as a commodity system, or on fashion as cultural signification. Identity through fashion is understood as 'a socio-cultural force bound up with the dynamics of modernity and post-modernity; an intangible system of signification'.[6] [#_edn6] Fashion theorists have shown little interest in the emerging field of soft wearable technologies. Systems of fashion education and manufacturing have had limited engagement, with the design and production of wearables using technology supply chains rather than garment production systems, and where 'usability' rather than 'fashionability' has been the focus.

In considering approaches to fashion theory that might better engage with notions of embodiment and materiality and relate more closely to the discourse on wearable technologies, feminism would seem to offer a relevant framing. However, feminist theory in fashion has tended to engage with the oppressive effects of the fashion system and the politics of identity through dress. Ilya Parkins claims that while 'many of the philosophically informed works on fashion that have appeared in the last decade are marked by analysis that might be said to dovetail with larger feminist theoretical concerns … none of these texts is written from an explicitly feminist position'.[7] [#_edn7] The unique corporeal and material dimensions of dress have been ignored. 'Still missing is a strong feminist theoretical literature that considers the

cultural significance of fashion as a textual and material system.'[8] [#_edn8] Parkins introduces new materialist approaches, specifically the work by feminist theoretical physicist Karen Barad on 'Agential Realism'. She suggests these ideas could inform a mutuality of discourse and matter which would open up new ways of thinking about fashion and feminism, where phenomena are produced through complex 'intra-actions of multiple material-discursive apparatuses of bodily production'.[9] [#_edn9] Barad coined the term 'intra-action' as a challenge to conventional understandings of interaction, epitomised in fields like interaction design which are based on subject/object relationships. Intra-actions, Barad claims, involve a mutual constitution of entangled agencies where bodies are not limited by physical boundaries, instead becoming 'material-discursive phenomena'. This metaphysical reorientation of bodies and things suggests new conceptual approaches to smart textiles, digital fashion, and wearable technologies.

The 40-year history of smart textiles and soft wearable technologies has been categorised in different stages, based on levels of technology integration, wearability, and manufacturability. These phases include early stage devices where hardware was strapped on the body or attached to clothing, the development of smart fibres and textile structures attached to microprocessors, and recent developments of fibres and yarns that have sensors, transducers, actuators, and data processors embedded in them and can be structured into fabrics. While these technical developments are critical to

reliability, functionality, and commercial development, the characterisation of soft wearable technologies which can sense, respond to, and communicate from, between, and beyond human bodies, material artefacts, and environments must take aesthetic and philosophical dimensions into account. The importance of touch, kinaesthetic, and proprioceptive experience, that are intrinsic to fashion and textiles, can be seen as part of an ontological reorientation of the human as part-of rather than apart-from the world, akin to Barad's 'ethics of knowing and being' which recognises the situated, relational nature of a broad range of phenomena. The projects discussed in this article engage with this new paradigm.[10] [#_edn10]

Textiles and the body

Textiles are the raw materials of dress. Textile knowledge includes both explicit/technical and tacit/embodied dimensions. For example, the 'hand of fabric' is a term used to describe the tactile evaluation of fabric through the sensation that is felt by the fingers if the cloth is handled. The feel of a textile, its roughness, smoothness, pliability, and thickness, is important to the design, performance, and consumer appeal of garments.

A number of different types of cloth handle analysis have been developed beginning with F.T. Peirce, but all possess limitations. The origin of the hand of textiles is embodied and subjective, related to individual experience, perception, and sensitivity of the skin receptors of the human hand. There are different approaches to the analysis of textile hand in a

subjective manner, with most depending on agreements reached between groups of experts, using methods of embodied knowing to analyse materials that are both ground and boundary of embodied experience. This process is reflexive, textiles 'facing and interfacing skin and vice versa … implying folding, unfolding and refolding into each other'.[11] [#_edn11] This process has not yet been fully replicated by technology.

Objective methods generally provide certain mechanical parameters that are understood to present components of hand, such as fabric stiffness and compressibility. However, there are anomalies between the mechanical behaviour and properties of a textile and the way a textile feels that are not always explained in mechanical models. To overcome this problem, a number of approaches combine objective and subjective analysis. A third approach, biomechanical modeling, attempts to represent material and human factors that affect the way a textile feels. This encompasses a complex range of phenomena including the mechanics of fibres, yarns, textiles, and clothes and their relationship to the body through physical responses to external stimuli; neurophysiological processes for decoding stimuli through the bio-sensory and nervous systems inside the body; and neural responses to psychological sensations. While the complexity of such models is increasing, they cannot yet compete with 'the hand' of the expert analyst.

The hand of textiles indicates the significance of material phenomena and ways of knowing

the world through the senses rather than knowing through objective, mechanised systems. Mădălina Diaconu has written about the senses in Western aesthetics and their extensive scientific study. She has recognised the devaluation of the 'secondary senses' of touch, taste, and smell.

> Civilization has proclaimed man's autonomy and independence from nature as an ideal. The liberation from instincts implies the metaphorical equation, 'sight is power': the higher the position one conquers, the better one is able to see and control the world that lies, ordered and classified, at one's feet. If vision empowers knowledge, it also impoverishes sensory diversity and makes reality feel less real: the visual … loses contact with the environment, the world threatens to become an abstraction and, along with it, one's own body. The place from which the world opens itself to the domineering gaze lies outside the world. Correspondingly, distance and contemplation characterize the Kantian aesthetic subject. Conversely, a defenestration of the subject occurs by rehabilitating touch, smell and taste; humans descend again into the middle of the world and its whirl.[12] [#_edn12]

The ontological reorientation of subject and object that Diaconu implies can also be recognised in the emergence of digital fashion and smart textiles, where a range of sensory inputs and outputs are engaged through and between the body and technology, where data is not just abstracted but can be embodied and

enacted. Miranda Smitheram's project The Hand of the Cloth: An Ontological and Aesthetic Unfolding through Digital and Virtual Materiality explores a merging of physical and haptic approaches with both material and virtual textiles. This investigation has led to new aesthetic outcomes, expressed through physical, virtual, and digital interfaces.

The description of cloth as a 'second skin' that mediates between body and environment has a long tradition within the discourse of dress and textiles. As the human body's largest organ, skin forms a protective barrier between the inside and outside of the body, providing contact with the environment via receptors which can respond to regulate the body accordingly, for example through thermoregulation. While traditional textiles have emulated or enhanced some of these functions of skin, the notion of textiles as a second skin goes beyond functionality, as clothing is primary to embodied experience. The concept of skin as sensory interface or fringe of the virtual has been discussed by media theorist Mark Hansen. The idea of a second skin – of textile as interface – re-emerges and folds in the field of smart textiles, where a sensor can be constructed using conductive yarn and the structural and mechanical properties of a textile; or a textile can react, using electronics or shape alloys, to change the configuration and properties of the textile and recursively trigger different experiences or reactions on the part of the wearer.

Jane Harris writes of digital skin, drawing

attention to the relationship and language between idioms emerging from computer graphic imaging that have become synonymous with everyday terms like 'skin', 'surface', and 'texture' – words that have long been part of fashion and textile vocabulary. This language has begun to intersect physical and digital meaning, and textile designers are engaging in the creative development of digital surface design and associated concepts. Caroline Steven's project Digital Dynamics: An Interactive Design Process for Generating Knitted Textiles explores new ways of designing with interactive textiles using the data generated through the designer's performative engagement with the textile to inform new methods of digital knit design. This approach involves a hybridisation of digital and material languages challenging conventional approaches to knit design and production processes.

Digital media tools and technologies are central in these new textile practices. However, technologies and their histories are not linear. The relationship between textiles and computing was formative, with Charles Babbage proposing the use of punch cards, inspired by the Jacquard weaving loom, to programme and store data in his *Analytical Engine* (1837). These intertwined histories of textile and digital technologies are a form of mediation.

Mediation and remediation: Surfaces, frameworks, sensibilities

Designer Pauline Van Dongen suggests that while fashion and wearable technology are part

of a continuum, smart fashion technologies must be recognised as another, distinctive medium. The notion of a medium as intervening agency or means by which something is conveyed is used across a range of creative and technical fields. The term mediation, drawn from the field of media studies, emphasises the heterogeneity of transformations arising from media across complex temporal and social spaces rather than any single media logic. This idea challenges the linearity of modernity and the futuristic sense of technological progression evident in the futuristic discourse of wearable technologies.

Mediation implies a different perspective, one that allows for a recognition of diverse disciplinary and technological histories and new combinatorial strategies as heterogeneous intersections of ideas. All current media is a re-mediation of some preceding medium. Remediation is an integral practice to both new and old media forms that continually inform and react to one another. The notion of remediation is important in domains like soft wearable technologies, where knowledge and practices from traditional fields such as textile design and garment construction are linked to new forms of electronics and computation. Notions of textiles as a second skin and smart textiles as sensory interfaces can be understood in terms of remediation.

The field of media studies has tended to focus on forms of mass media, with an emphasis on screen technologies and visuality. While the screen and its mediation via mobile communication, social media, and interfaces in

communication and social spheres would seem to have limited relevance to wearables, some consideration has been given to concepts of clothing in relation to screen as surface and digital materiality. The screen, it has been suggested, is remediated via smart fashion and wearables. Recognising a fundamental relationship between clothes and the body, Stella North describes the clothed surface as a 'worldly plane onto which the body, which is to say the embodied self, extends'.[13] [#_edn13] Clothing, she suggests, is a body/world interface, 'the layer of the world closest to the body, and the layer of the lived body closest to the world'.[14] [#_edn14] This gives rise to a sense of 'being of a surface' that is fundamental to the ways we engage with and experience the world. North claims that this sense of body-world interface challenges current media theory notions of screen, where visuality has dominated, separating the spectator from that being seen and reinforcing the positioning of subject and object.

Nigel Thrift addresses the relationship between screen, software, and the body, identifying an 'active mediation of machines of various kinds'.[15] [#_edn15] In addressing the development of new forms of digital materiality, he suggests that the relationships between new surfaces, frameworks, and sensibilities produced through these 'technological infrastructures' result in a second skin of new forms. The first register, that of surface or screen, he describes as a new ecology, a 'vast epistemic apparatus and a new form of inhabitation'.[16] [#_edn16] The second register, that of software as framework, is an

invisible, ubiquitous technical substrate that is often taken for granted. Software, he suggests, is not just an intermediary but is an agent of material complexification, with a theoretical background that is embedded into the interstices of code itself. The third register – that of sensibility – is the human body 'thought anew'. Here the body forms a new set of informational surfaces through which the combination of machine and theory 'create a new "inside" which is also simultaneously an "outside"'.[17] [#_edn17] These three framings, Thrift suggests, contest traditional subject/object relationships and notions of corporeal integrity that have been essential to modernist concepts of human being. In smart textiles, the fabric surface and its programmable infrastructure sit on and responds to the body, whereby notions of inside and outside the body are blurred.

Amit Gupta's research into Emotion Sensing Textiles that detect (internal) emotional states through touch or skin contact with the textile structure, using software to collect, read, and translate data that are communicated externally through the textile surface, engages in processes of active remediation that invert normative subject/object relationships. The concept of remediation provides a bridge between media studies and smart fashion and suggests new approaches for designers of soft wearable technologies. In recognising these emerging forms as both media and clothing, the histories and methodologies of textile design and garment manufacture can be considered alongside the histories of technologies, so that these new and old material and media forms

can inform and react to one another. In doing so, the dual nature, or to use Jussi Parikka's term for intrinsic material and digital dimensions, the 'medianature', of soft wearable technologies is highlighted.

Digital materiality

The concept of digital materiality has emerged over the past twenty years, drawing from a number of disciplinary fields. In the area of information systems digital artefacts, including software programs and operating systems, have posed a special problem. They are not just physical artefacts that can be touched or interacted with, nor are they merely intangible abstractions. These new types of things have challenged distinctions between the material and the virtual. This 'material turn' was recognised in the field of interaction design by Ishii & Ulmer, who understood tangible interactions as a bridge between the digital and physical. This engagement with tangibility led to a re-examination of computation in more material terms. Wiberg and Robles described this as a move 'away from the long-standing preoccupation with distinctions between atoms and bits and towards the articulation of formal relations at a variety of scales'.[18] [#_edn18] This reconsideration of object/subject frameworks based on mediation through new forms of technological materiality has led to an ontological re-orientation that decentres the human, recognising the notion of active, living matter and the vital materialism we are part of. Daniel Miller talks of 'sapient materiality', where both consciousness and cognition are 'bound to the specifics of

materiality rather than defined by their opposition to a material world'.[19] [#_edn19] Sapient materials such smart textiles pose a challenge to dualities of material and immaterial, exterior and interior, body and mind, object and subject.

Barad's philosophy of agential realism recognises that material entities are not ontologically distinct, but are constituted in relations. For Barad, 'phenomena are produced through complex intra-actions of multiple material-discursive apparatuses of bodily production'.[20] [#_edn20] She suggests the term 'intra-action' to signify an inseparability of objects and agencies of observation, a blurring between knower and known. The notion of intra-action contests the term interaction, originally developed in the discourse of Human Computer Interaction (HCI) where understanding 'the user', 'the problem space', and 'the opportunity space' are paramount. Interactivity in the HCI context is based on the assumption that entities in a relationship are discrete and exist ontologically prior to the relation. Barad argues against such fixed positioning, claiming that identity formation 'must be understood as a contingent and contested ongoing material process through which different identity categories are formed and reformed through one another'.[21] [#_edn21] This performative, intra-active dimension blurs boundaries between people and things, and opens up new theoretical and methodological spaces in the discourse of digital fashion, wearable technologies, and smart textiles.

In addressing the relationship between new materialism and media theory, Jussi Parikka has recognised that methodologies and vocabularies need to be able to speak 'not only of objects, but also as much about non-solids and the processual, the weird materiality inherent in the mode of abstraction of technical media so we can understand what might be the specificity of this brand of materialism that we encounter (but do not always perceive) in contemporary media culture'.[22] [#_edn22] The fields and artefacts of digital fashion, wearable technologies, and smart textiles, in their particular material and digital configurations, relationships to and beyond the body, and their converging, multi-disciplinary histories of technology, require further consideration in regard to their medianatures and the ontological challenges these new framings bring.

The projects

Here, three design-led, speculative, smart fashion and textiles projects conducted by postgraduate students at the Auckland University of Technology (AUT) are considered in relation to the prior theoretical discussion. The author was supervisor of these research projects, and engagement with the researchers has been critical to this developing discourse. Concepts of mediation, digital materiality, and embodiment are related to particular aspects of these projects.

Case One: Emotion Sensing Textiles (2013-2015)

PhD candidate Amit Gupta worked on a project

to design Emotion Sensing Textiles (2014) that can detect and respond to changes in human emotional states. His interest was in developing wearables to assist people in better understanding their own emotional states. Sensors, knitted into the textile using conductive yarn, were used to detect changes in the electrical resistance of the skin (galvanic response) caused by stress. The level of stress was communicated via colour changes using light emitting diodes (LEDs) integrated into the surface of the textile, rather than through any quantitative reading. Gupta was interested in developing self-awareness through more empathetic and aesthetic forms of communication via a textile interface, rather than measuring and communicating data via a mobile interface, as many health-related wearables do.

An early prototype of the sensor/LED system was activated by placing the fingers on the knitted surface, triggering the colour change response in a single LED. Exhibited in Eindhoven in 2014, this work prompted strong audience engagement and reaction. By providing feedback on stress levels the textile system acted as an interface into the self. Several audience members, surprised by getting higher 'stress' readings, took time out to sit down, breathe slowly and relax, before returning to check to see if their stress levels had reduced

This system was extended in an Emotion Sensing Dress (2014) designed by a team including Gupta, PhD candidate Donna Cleveland, and artist/technician Kim Newall

(Figure 1). The dress was commissioned by the Director of the AUT Business Support Awards to be worn at the awards ceremony. The design brief was to create a smart dress that would be a conversation piece, conveying AUT's brand and its focus on design and innovation. The LEDs were scattered across the voluminous collar of the dress. The colour of the LEDs shifted from blue (calm state) to mauve/pink (stimulated state) to red (agitated state), depending on the stress levels of the wearer. This dress showed how the borders of inside and outside the body can be challenged or blurred through the digital materiality of smart fashion.

In public, most people will try to hide nervousness or stress. There are formal dress codes governing occasions such as award evenings, for example tuxedos and other 'black tie' forms of menswear, or women's evening gowns. These forms of dress signify social standing rather than sensation or feelings. The smart dress acted as a personalised interface, subverting the convention of evening dress by communicating the wearer's inner emotional state and prompting engagement. Although the purpose of the dress was rhetorical – to be a conversation piece rather than serve any specific function – its behaviour proved to be extremely helpful to the director's personal assistant. She reported that the dress with its sparkling LED collar stood out and was easily visible in the large crowd attending the awards night, helping her to easily locate the director. When the LEDs were glowing blue she knew things were going smoothly; when they shifted into the mauve/pink spectrum she knew to

keep an eye on things; and if they moved into red she realised there could be a problem and that she needed to get over to help the director. This smart dress was not just interactive, communicating between the wearer and the dress, but elicited an intra-action between the wearer, the artefact, and other people, creating a sense of empathy and engagement.

Fig. 1: Emotion Sensing Dress. D. Cleveland, S. Trottman, A. Gupta, K. Newall, 2014.

Case Two: Designing with Interactive Textiles (2015-2016)

Caroline Stephen's Master of Creative Technologies Project, Digital Dynamics: An Interactive Design Process for Generating Knitted Textiles (2016), explored new ways of designing with interactive textiles. This process dealt with the performative behaviour of interactive textiles to inform new methods of digital design and making. The project engaged with notions of digital materiality and processes of remediation to disrupt conventional, linear, textile and knit design processes. A cyclic, generative process was developed through the production of conductive knit samples; manipulating these samples to gain tangible feedback on the

electronic behaviour of the textile; using this data to generate coded patterns for a second series of knitted samples produced on a digital knitting machine; and again, testing the electronic behaviour of these textiles to generate more data to be fed back into another generation of textile designs produced as knitted Jacquard fabric. Stephen recognised this generative act of designing with data as a process of 'decoding and encoding matter as digital materiality' through modes of abstraction and making.[23] [#_edn23]

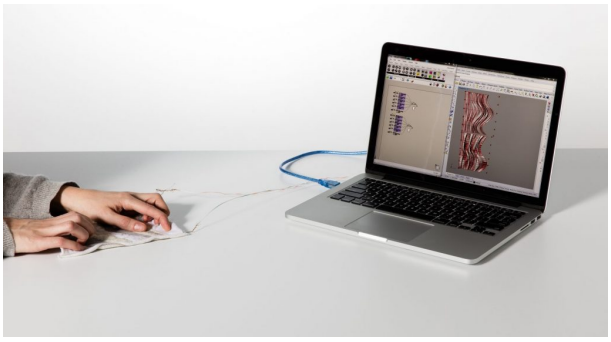

Fig. 2: Manipulating and testing a conductive knit sample to generate pattern. C. Steven, 2015.

In reflecting on this design process Stephen identified these smart kitted materials and the technologies they were produced and measured on as 'collaborating agents' that encouraged a design process 'of interaction and collaboration with active materials and self-assembling matter'.[24] [#_edn24] Barad's description of contingent and contested ongoing material processes that involve 'multiple material-discursive apparatuses of bodily production' resonates with Stephen's approach.[25] [#_edn25] Working with the traditional medium of knitted textiles, through a generative sampling process, the embodiment of the designer rather than a

wearer was central to this project (Figure 2). Stephen's haptic engagement with both textile surfaces and the digitised readings of their electronic behaviour on screen and back into knitted data structures as new textile patterns or surfaces is a process of remediation that can be related to Thrift's model of new surfaces, new frameworks, and new sensibilities produced through technological infrastructures.

Fig. 3: Knitted data structures. C. Steven, 2015.

The entanglement of physical processes of making with digital knit technology included: abstract programming and mechanical production; the use of tangible interfaces as textile surfaces with electronic behaviours governed by the yarns used, the way conductive and non-conductive yarns are configured in the textile design and the way they are manipulated by the designers hand; the performance of these knitted textile structures and surfaces through the 'hand' of the designer and onto a screen as mathematical data, transformed in turn into imagery and back again into new textile designs (Figure 3). These processes challenged traditional methods of designing knitted textiles, suggesting an ontological shift through the inseparability of material and technological

things from human knowing and creation.

Fig. 4: Remediated textile design (detail of Knit Data Jacquard 2). C. Stephen, 2016.

The final textile designs that emerged through this generative process of remediation were distinctive in their combination of technologically-generated and human-selected elements (Figure 4). Aesthetic decisions including the choice of yarn and stitch structure and the use and placement of colour in terms of hue were choices made by the textile designer, mediated through the parameters of the digital knitting machine used to produce the textile. The pattern or figuration of the textile's surface design was produced through the digitised materiality of earlier samples, manipulated by the designer's hand and through various hardware and software technologies used to capture and represent the data. The human and the technological were inextricably linked through this process where performative methods, engaging the designer, the textile, and both software and hardware technologies, generated highly original textile designs as well as informing the development of new methods and understandings through experimental and embodied practices of making.

Case Three: Physical, digital, and virtual textiles (2014-2016)

In her PhD project The Hand of the Cloth: An Ontological and Aesthetic Unfolding through Digital and Virtual Materiality (2016), Miranda Smitheram investigated relationships between bodies, textiles, and technologies. This project led to the development of new design methods and resulted in the production of a body of creative work that integrated digital media with speculative acts of making and traditional textile techniques. Smitheram used motion capture (Mocap) – a technology normally used for tracking human body movement – to capture cloth dynamics and then translated and manipulated this movement data through various digital processes into a number of formats including printed textile designs, animations used as videos and as projections onto cloth installations, and virtual textiles presented as data clouds and video.

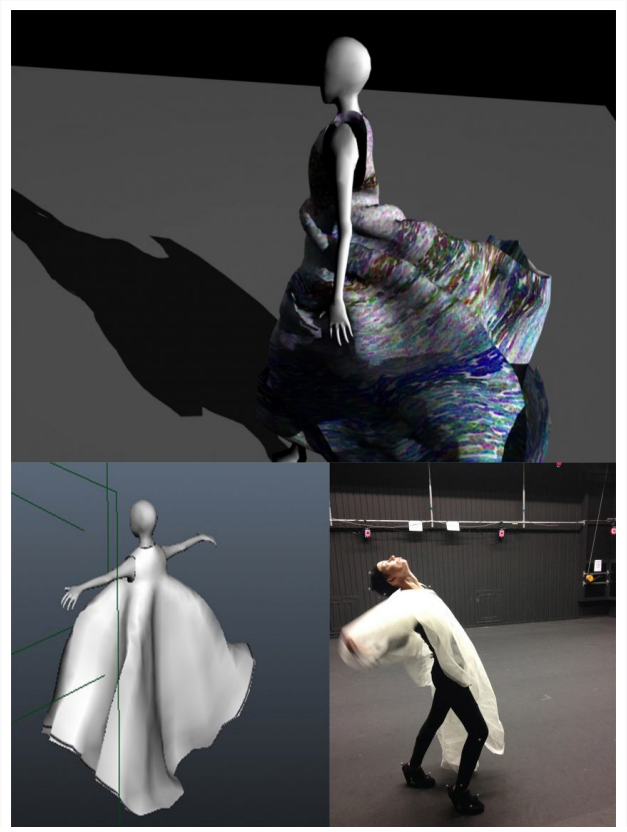

Fig. 5: Model and avatar (liminal dress). M. Smitheram, 2013.

The hybrid methodology developed in this project involved a merging of physical and haptic textile approaches with digital materials, leading to new aesthetic outcomes that emerged through this recursive, intra-active engagement with physical, virtual, and digital interfaces. Through a process of experimentation and drawing from her background as a fashion and textile designer, Smitheram engaged with a range of new processes and technology platforms associated with 3D digital media. Emphasising both the materiality and the performativity of cloth, its movement was manipulated by models or assistants and recorded (Figure 5). This information was then translated into new mediated surfaces that contained echoes of the human body extending through the data into forms of representation. In this context 'the hand of the cloth' became a critical linkage between the physical body and the digital world. Parkins has recognised the inextricability of material object and subject, noting that 'garments cannot signify without a body, real or imagined, and that even an unworn garment refers to the materiality of an eventual wearer'.[26] [#_edn26] In Smitheram's project embodiment was implicated across different technological and material registers.

In combining a fashion and textile designer's process with digital making, Smitheram also employed a process of remediation. This included the use of glitches, mash-ups, and cut-

and-paste methods as well as hacking the formal conventions of the software, for example manipulating the grid-like, wire frame structures the software uses to represent the surfaces of three-dimensional objects (Figure 6). While these technologies are common in fields like 3D animation and visual effects, they are not understood or used in the language or methods of textile design. Her approach recognised the potential of digital-making processes for iterative concept and design development and the generation of infinite varieties of imagery.

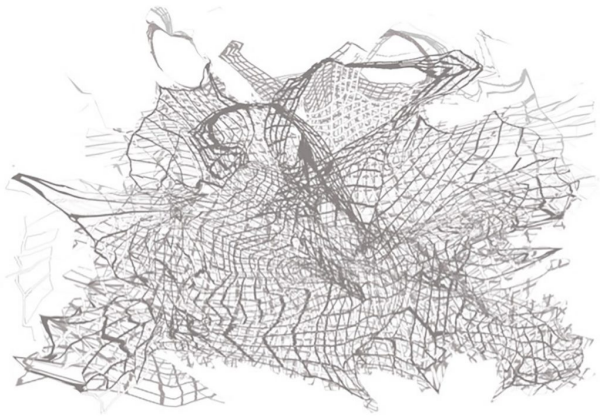

Fig. 6: Warped, layered mesh form print. M. Smitheram, 2015.

Remediated digital imagery was built up in a layered process through the designer's performative engagement with data, process, and code. This generative design method can be contrasted with a typical fashion design process that iterates through sequential prototypes that are incrementally refined. The imagery was exported into a variety of formats including textile prints, animations (Figure 7), and projections (Figure 8).

Fig. 7: Still from virtual dress animation. M. Smitheram, 2016.

Fig. 8: Installation with projection. M. Smitheram, 2016.

The research investigated possibilities for digital fashion and digital textiles and their material relationships. Smitheram's concern with the representation of textiles and dress through digital and physical media involved surfaces as a series of digital skins, overlapping physical and conceptual applications to explore the nature and possibilities of surface design. This approach led to the development of new textile design methods, working with 3D data capture, manipulation, and translation across different formats and presentation media. The project was underpinned by a philosophical

framework that addressed notions of materiality, embodiment, and mediation in relation to physical, digital, and virtual forms of interface and representation.

Conclusion

The concepts and theories discussed here, drawn from different disciplinary domains and research investigations, highlight some of the issues and frameworks that are emerging in the field of soft wearable technologies, which includes areas of digital fashion, wearable technologies, and smart textiles. While each of these areas can be defined according to their original disciplinary backgrounds (fashion, technology, and textiles), in the broader field of soft wearable technologies they merge and entangle with one another.

The new materials and artefacts considered in this essay raise a number of theoretical issues beyond the scientific frameworks and associated technical and functional concerns that governed early smart textile development and discourse. The area of smart wearable technologies is an interdisciplinary domain and requires different theoretical and methodological frameworks to better support the development of these particular new forms that combine dress and device, material and digital, bodies and technologies. The concepts of mediation, embodiment, and materiality discussed in this essay are drawn from areas including media studies, fashion theory, embodied cognition, and new materialism. They introduce new ontological perspectives that are inherent to this emerging field, where traditional subject/object relationships are

called into question.

The three projects discussed in this essay are all engaged with textiles, bodies, and new technologies, but have distinctive orientations and outcomes. Gupta's project approaches the design of smart textiles as an interface into and beyond the self, attempting to detect and communicate emotion. Gupta's work extended from an initial textile-based haptic interface prototype to the design of a smart fashion application (the Emotion Sensing Dress, Figure 1). Here the intra-action with the dress was extended to include the audience, emphasising not just the materiality of dress, its wearer, and its technologies, but the materiality of discourse with the audience.

The concepts of mediation, embodiment, and materiality outlined in this essay introduce new perspectives that help articulate the particularity of this new field, the ways it contests traditional subject/object relationships and opens up new methodological possibilities. Caroline Stephen's project engaged with smart knitted textiles as generators of new textile surfaces. The focus of her project was both methodological and artistic, resulting in a new design process and a series of original textile samples (Figure 4) with unique aesthetic qualities. This project utilised new materials such as conductive yarns and technologies for measuring electronic behaviour, microprocessors for converting data into patterns, software for manipulating images, and digital knit software to translate imagery into knit designs for production on digital knit machines. The relationships

between the material and digital dimensions of this project were folded and refolded into one another in a generative process of remediation and reflection. In this work the performative and embodied role of the designer is evident in the haptic manipulation of the original smart textile samples, the intra-action with the various material and technical dimensions of the project, and the aesthetic qualities of the final textile samples produced.

In exploring physical, digital, and virtual dimensions of textiles and dress, Miranda Smitheram employed 3D technologies and surface design techniques to realise a theoretically and aesthetically complex body of creative work. This engaged in and articulated processes of remediation between different technologies, including both hardware and software and across various tangible and intangible media platforms. Her attention to the haptic, kinetic, and aesthetic qualities of textiles extended through the representation of textiles in different formats and mediated states including wireframes and Mocap data clouds. The human body, its presence and absence, was a critical focus in this process. The hybridisation of digital and material languages and their remediation challenged conventional approaches to textile and garment design and introduced new generative methods that resulted in highly original aesthetic forms (Figure 6).

While the fields of fashion and dress theory and of media studies have been slow to engage with the emerging areas of digital fashion, smart textiles, and wearable technologies, new

theoretical perspectives, including new materialism and post-cognitivism, that recognise phenomena rather than objects and agencies of observation, have opened up a discourse that connects these new mediated forms. The area of soft wearable technologies is a transdisciplinary domain and the intrinsic work of negotiating disparate boundaries is vital to its ongoing development. Dress, Parkins notes, 'underscores the materiality of discourse'.[27] [#_edn27] The entanglement of material object and subject are undeniable in fashion and textiles. These dimensions of material discourse, explored through remediation and embodied understanding, are leading to new methods of smart fashion and textile design, different understandings, and more reflective applications. These new sapient materials and smart wearables introduce ontological perspectives that pose a challenge to dualities of material and immaterial, exterior and interior, body and mind, object and subject. In this they open up fertile ground for speculative inquiry and the development of conceptual and methodological tools with intra-active design implications.

Author

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research is concerned with innovation through design and new technologies, with a focus on interactivity, e-textiles, and collaboration. Frances has led several initiatives to enable new forms of creative practice including the instigation of a successful New Zealand government-funded project to establish AUT's Textile and Design Lab in 2007. She was the instigator and lead author in a second New Zealand government-funded project that led to the formation of Colab, a 'collaboratory' for creative technologies teaching, research, and partnership.

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[16] [#_ednref16] Ibid.

[17] [#_ednref17] Ibid., p. 246.

[18] [#_ednref18] Wiburg & Robles 2010, p. 68.

[19] [#_ednref19] Miller 2005, p. 34.

[20] [#_ednref20] Barad 2001, p. 87.

[21] [#_ednref21] Ibid., p. 99.

[22] [#_ednref22] Parikka 2012, p. 98.

[23] [#_ednref23] Steven 2016, p. 1.

[24] [#_ednref24] Ibid.

[25] [#_ednref25] Barad 2001, p. 87.

[26] [#_ednref26] Parkins 2008, p. 506.

[27] [#_ednref27] Ibid.

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