Amanda Smith

Past, Present and Future: A haptic approach to mass-production seamless knitwear technologies

Abstract

Knitting is a ritualistic process of making which is based on binary multiplications of stitch formations, the knit and the purl. Knitting is culturally embedded within our society and wardrobes; it takes the form of the craft object to the avant-garde garment. It has a duality of making, that of hand and machine, which parted ways at the onset of the European industrial revolution in the sixteenth century. It is only in the last twenty years that the machined has come full circle back to its craft roots, with the capability to produce objects on 'the round' through seamless knitwear technology.

This paper, engaging my current PhD research, concerns a critical assaying of the impact of seamless knitwear technologies, particularly with respect to the role of design and craft in its applications and outcomes within a garment design process. This is achieved through a process of reflective development working both inside and outside of the internal seamless knitwear design system. By combining the functional processes of the technology with intuitive craft responses to each garment, affective design qualities become embedded within garments produced via a mass-production design system. It is the evocation of past design knowledge as applied to the present technological boundaries of computational design systems that opens the shuttling of duration's pastness and futurity, finding the interstitial space in which to think the time of production differently and introduce a haptic aspect.

Computational design methods in the knitwear industry have a genuine impact on the skill sets of practitioners. Such an impact requires new approaches to design method as well as new ways of understanding design histories and the possibilities of futures. This research challenges past design methods and re-kindles influential creative past experiences. The traditional Japanese aesthetic of wabi-sabi was one past experiential influence that surfaced during this research, through its proximate resonance and dissonance with seamless knitwear. In its current applications, seamless knitwear appears to be antithetical to traditional Japanese approaches to creativity. To engage this 'present' of a complex of technological, historical and aesthetic forces that distend contemporary knitwear practices, my paper aims to ask how we might think the time of production differently and in this find interstitial spacings in computational design processes that invigorate a more traditional understanding of design.

> Memory is not constituted after present perception, but is strictly contemporaneous with it, since at each instant duration divides into two simultaneous tendencies, one of which goes toward the future and the other falls back into the past. (Deleuze 1991: 118)

Keywords

seamless, knitwear, design, mass-production, haptic

Twisting folded narratives

Knitwear became part of fashion incrementally over many centuries, predominantly being worn as underwear and not becoming known as outerwear until the early 1900s. All knitwear garments and accessories, such as the knitted stocking, were hand-knit until the sixteenth century when, due to the demand created by the wearing of hose, William Lee developed the mechanised stocking-knitting frame. This produced a coarse knitted fabric, fashioned into a stocking, heralding the beginning of industrialisation of the knitting industry and the possibility of mass-produced clothing (Black 2002, 2012).

Knitwear is now seen as a subculture of fashion and crisscrosses borders and boundaries found within fashion design, technicity, production and cultures. It has a duality in its modes of production: domestically perceived hand knitting and machined industrial production. The image of the domesticity of knitting remains embedded within the imagery of knitwear as a product, even though industrialised knitwear is now produced on some of the most advanced technology available for clothing production. Whether evoking a domestic romanticism embedded in knitwear history or emphasising computerised knitwear technologies,

knitted textiles are essentially fabricated in the same way, through the use of a single piece of yarn. The single thread is inter-looped around itself to form a surface fold, a continuous line-becoming-garment, each stitch expressing its production and that of the garment that carries it. It is through this process of continuous yarn wrapped around itself, stitch interlaced to stitch, multiples of knit and purl, that the historicity of knitting is evoked through its evidential links to a craft context.

Knitwear has followed parallel journeys of hand-knit and mechanised production. Up until the 1950s, mechanised knitwear was limited by sheer mechanical capability, with hand-knit garments more sophisticated than those produced by machine (Power 2007). There were design innovations driven by knitwear designers and technologists alike during the 1950s and 1960s, such as McQueen patenting the Basque beret technique of *flechage* (1950s) as a technique to make outerwear, not just berets. Elsa Schiaparelli and Emma Pfauti had both developed ways of making individual hand-knit garments with no seams, whose principal concern was body-fit (Power 2007). However, industrialised knitwear technology was not advanced enough to be able to duplicate these techniques. It has taken another seventy years for this to be achievable, as mechanisation in the form of seamless knitwear technology.

Throughout history, fashion has influenced and driven industrial and technological developments but, equally, shifts in technology have also influenced changes in fashion. Power discusses the development of seamless garment technology and also notes that the first generation of WHOLEGARMENT® machines released by Shima Seiki Manufacturing in 1995 didn't have the initial impact on the industry that was originally predicted. Power suggested: 'the product range capability of the first machine was too restrictive for the fashion arena' (Power 2007: 11). Other industry experts (Hunter 2004–5; Spencer 2001) noted that the industry generally was not ready to embrace seamless knit technology. Such innovation had moved beyond the industry's mind-set and designers' understanding. This research presents another thought-image. It recognises the *timeliness* of developments in seamless knitwear and its utilisation by knitwear designers. We see how the pull and push between these two, technology innovation and design innovation, are reliant on one another. They fold but are often asynchronous, out of time with one another. This means they produce new time, which is to say, a future that is the new. Such folding is the new. Hence, this research raises the question of what is the current relationship between technology and design and investigates the slow uptake and use of seamless garment technologies within the designer knitwear industries for production that is not of a standardised nature. This paper researches the design possibilities and limitations using seamless knitwear technology, at a point when this technology is readily available but seemingly underutilised.

This case study explores the creative options open to knitwear designers when using seamless knitwear computerised technologies, to ascertain if it is possible to fully engage with the notion of three dimensionality of creative knitted form building when using this technology. This was accomplished through a series of practical experiments using seamless knitwear technologies from an experienced knitwear designer's perspective, but one which had little to no technical CAD training or knowledge. This lack of technical knowledge allowed an un-premeditated approach to be taken when interacting with the technology, and thus had the potential to open up new ways of thinking about and making knitwear. This method of approach prevented the technology from dictating and supressing the creative design process. By taking a more flexible approach it allowed for the adaptation of the standardised software to be integrated with an iterative design process. An open approach to the structured commercial design and production system of seamless knitwear technology enabled the design process to be more creative and haptic as an integrated design philosophy. This approach resulted in the production of more unique and expressive seamless knitted garments, reflecting a three dimensionality in form.

This study re-thinks the manner in which the design process is approached through invoking the aspect of maker as they connect with the materiality of the made. The incorporation of wabi-sabi, an ancient Japanese ethos, as an approach to 'being' – or in this study an approach to 'making' – opens this interval, creating a new way of entering the technical standardisation of seamless knitwear technicities. By evoking wabi-sabi as part of the design philosophy within this study, the haptic elements of a garment's materiality and aesthetic nuances of creative details are re-incorporated back into a mechanised and standardised commercial practice.

Contextual framework of study

This study took place in the New Zealand locale and, as such, this was the first community of seamless knitwear design outputs to be analysed.

In assessing the relationship between knitwear design practice output potentials and the adoption of seamless knitwear technology, it was found that limited design styles were being produced. It was found that this technology was not being used for designer knitwear in New Zealand but for tourist wear of a predominately standardised and classic shape. Traditional knitwear design processes are based on the fabric development of a textile swatch, which is then knit to size to produce a front, back, and two sleeves. The required shapes are cut from this fabric using flat-pattern-making techniques. The development of seamless knitwear has proved to be the first major production swing away from traditional manufacturing processes which relied on an assemblage of parts of a garment and are reflective of this flat-pattern-making paradigm. The technical development of four needle-bed knitting technology created the ability to produce WHOLEGARMENT® knitwear, as explained in *Knitting International* (1995):

> The sweater is knitted into a cylindrical configuration by first separately knitting the body portion from the waist and the two sleeves from the cuffs, respectively. When these three portions achieve a predetermined length, they are integrally knitted together at the lower portions of the armholes. The sleeve caps are inclined through progressive reductions in the width, and the shoulder portions are knitted thereafter. (Mowbray and Spencer 1995)

A primary theme within this production model is the move from knitted fabric pieces, which were cut and sewn, to the more cost effective, seamless knitwear capability. The introduction of seamless knitting technology has manufacturing advantages, but these come potentially at the cost of design. The machines come with pre-installed design packages and, at this point, it appears that most companies in New Zealand either lack the design vision, the technical understanding or the need to develop their own internationally competitive designs which fully exploit this technology. Consequently, they tend to use 'ready-made' programmes with limited design aesthetics.

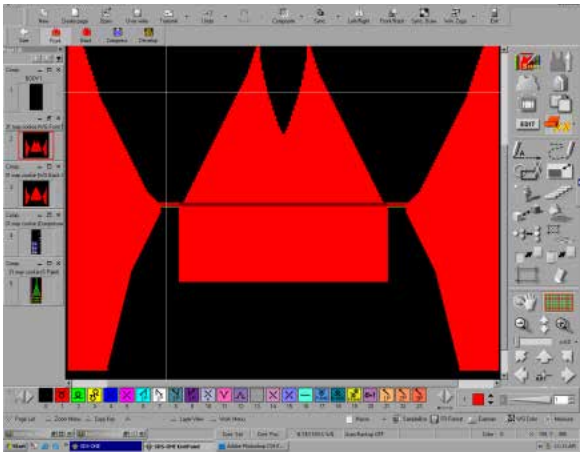

Figure 1. Basic shape from Shima pre-installed programme (Smith 2013).

Seamless knitwear processes

Ever since the advent of the role of designer made its way into the knitwear industry in the 1930s (Power 2007), there has been a technical and design divide. This divide has been both a gender and an occupational one. The gender divide is not, however, the main issue. It is only exacerbated by the different training procedures that designer and technician historically have had. Knitting companies generally train their technicians in-house; designers usually complete a university design degree, or previously a polytechnic or technical college qualification. They thus have very different knowledge bases (Eckert and Stacey 1994). This historic model of occupational roles within the knitwear industry has formed the basis for the development of the human interface with seamless knitwear technology. There are two separate programming systems,

one for the technician and one for the designer. This can be seen through the evolution of design systems for seamless knitwear, which for Shima Seiki culminates in the latest SDS-ONE APEX-3 design and programming system and for Stoll in the M1Plus design and programming system for knit-and-wear garments. This paper argues that even though seamless technology is a remarkable achievement, providing the first means to produce three-dimensional garments, its main focus has been on technical capability, or technical composition, in distinction to aesthetic composition. The rudimentary design systems developed for WHOLEGARMENT® technology lack all but the simplest capabilities for difference for the designer.

Seamless knitwear technology is promoted as having endless design possibilities, but the reality is that there is still a manufacturing and production focus on technical abilities. When a designer works with the 'Design' system which interfaces with the technical programme, 'Knitpaint', it continues to promote the traditional 'role' divide, along with a continuation of a two-dimensional knitwear design process. It does this through continuing to follow a scripted, standardised design process within the computerised imagery which is reflective of traditional cut-and-sew two-dimensional front, back and sleeve shapes. Having two CAD programming systems, one for technical and one for design, currently the programming systems replicate and renew established approaches to design and production, remaining entrenched within traditional industrial models for knitwear design and manufacturing.

When working on both the 'Design' system and the 'Knitpaint' system, flat two-dimensional images are generated by the computer programme's visualisation software. It is difficult to imagine these garments as anything other than versions of traditional mass-produced replicas of knitwear seen in our closets for decades. The flat block-like shapes, along with the designer's stitch selection options, where the designer can pick from ready-designed texture or basic colour patterns, all result in a design system at once cutting-edge technology from a technical perspective and yet nothing but a designer's colouring in tool. This research suggests that seamless knitwear technology is successful for mass-production and global markets, where design has become synonymous with pre-programmed shaping, embellished with surface decoration, colour or texture. Yet there is little support for the designer who wishes to explore the three-dimensional aspect of shape or form differentiations within knitwear (Smith 2013).

Figure 2. Design system stitch and colour developments (Smith 2013)

Wabi-sabi as a lived experiential affect

Wabi-sabi is an essential aspect to my research. It is more than a style of design, or an approach to making in the conventional sense of an aesthetic affect. Wabi-sabi is lived before it is practised. Or, rather, it is a way of living rather than something one applies to particular things. In this sense, it is closer to an understanding of style as that singularity by which matter folds and unfolds in its nuanced duration of development and change. The twin ideas of evanescence and the ephemeral embody the Japanese aesthetic known as wabi-sabi (Inouye 2008). Wabi-sabi forms an ethico-aesthetic sensibility that often describes traditional Japanese craft and art products. It has become known throughout the western world as an aesthetic. It is seen to represent a certain quality of craftsmanship and a design philosophy, which has been adapted and transferred into the everyday. It is, at once and without differentiation, singularly remote and ritualistic.

Wabi-Sabi is the art of *impermanence*, becoming-imperceptible. It relies on matter's processes of degradation through change as an object is made and ages, expressing an object's nuance in a Bergsonian sense (Bergson 1991). It expresses the organic nature of matter as the designer or artist works with material, responding to the flows of matter as an object is formed. This transient, fragile nature of wabi-sabi is constantly changing and is therefore never complete, constantly becoming, with forces–affects or sense-events constantly reforming or making their mark on an object or person, creating a singularity of form in a unison of matter–memory. Wabi-sabi's impermanence, inconsistency and incompleteness recognise the im/perfection of all things, and that whereby the hand of

the artist is expressed. It thus rejects perfection and a uniformity seen with mass-production processes, creating a singularity of affect connecting an artisan and the way of making. Creating in this way leaves room for a designer to respond intuitively to the emerging materiality of forming. This creates the *interval*, which allows the designer to move outside of known experience and an intentional object, to develop beyond representation as repetition of itself: 'only those who have transcended the boundaries of dualism, who have succeeded in stopping their internal dialogues, who are able to perceive the world in its "is-ness" are able to be creative in the truest sense of the word' (Juniper 2003: 95).

Wabi-sabi provides a method of making for this research project. Because of wabi-sabi's opening to temporal instability that seems polarised to seamless knitwear's standardisation, it opens a way of asking anew what this machine is capable of becoming: how to relate to it differently? How to comprehend it differently? Wabi-sabi is not a look being sought from the machine outputs. It is a way of artisanal following of the flows of matter as they became assembled in the modulating capabilities of a WHOLEGARMENT® machine. Wabi-sabi provides an asymmetrical fluidity to form building through the yarns used and responses to these and their materiality. It pushes the garments away from a known structural model, accessing further potentialities of de/formation. As each garment emerges, the reciprocity of affects– being affected happen in the expression of the flows of matter: intuition in action. By understanding the nuances of the machine, the nuances of the yarn and the nuances of their relations and potentialities, a style is developed – a way for matter to become texture, to find its own nuanced expression.

Experimental matter

Initially design development used orthodox methods for concept building: sketching initial ideas and trialling three-dimensional toiles on a mannequin. However, it quickly became apparent that neither of these methods was easily transferable to seamless knitwear technology. It was not possible to mime the technical functions of seamless knit technology when drawing or toiling, therefore complicating an ability to know how these initial ideas would be actualised. It became obvious that the design development had to be done on the CAD system attached to the seamless knitwear machine. This was the sole way to explore shape development having the same technical parameters or behaviour as a 'whole' garment without seams structuring the volume. Because of its seamlessness, the surface dispersions of intensities of the garment develop according to the plays of this structural absence, or void. Formations and deformations become programmable within the surface textures of garments via the modal essences of the seamless technology's functions. The initial garment experiment used the basic tunic as a starting shape and, through using partial knitting (*flechage*) on one side, it deformed the rectangular shape into a curve which, when worn on a body, was reinterpreted in movements around the body, its materiality creasing, causing it to drape and fold, opening to a play of signifying possibilities.

To create this de/formation, to alter the basic tunic shape, a new Package, or pac, had to be introduced, initially developed by the technician at the university textile and design laboratory. The imagery for where the pac will be used is drawn on the overall, front and back two-dimensional images at compressed-garment stage of registration. These become the areas of movement, caused by directional forces being introduced to the basic form. The pac is then registered through a 'package development' process, and the new pac is then incorporated with the other pacs that make up the basic garment structure. A series of garments were developed, all based on the basic sleeveless tunic shape and using a variety of wedge shapes placed on the garment using two packages developed by the technician. Through this experimentation, a range of points-of-inflection was trialled. Each garment was developed, knit, analysed and incrementally altered. With each garment, improvement notes were taken and garments placed on mannequins to observe the lines, proportion and the way that the garment draped. In this way a shape lexicon was developed. With each variation, a series of differentiated modulations were elicited, creating a contextual order of differences, building a signifying system of meanings.

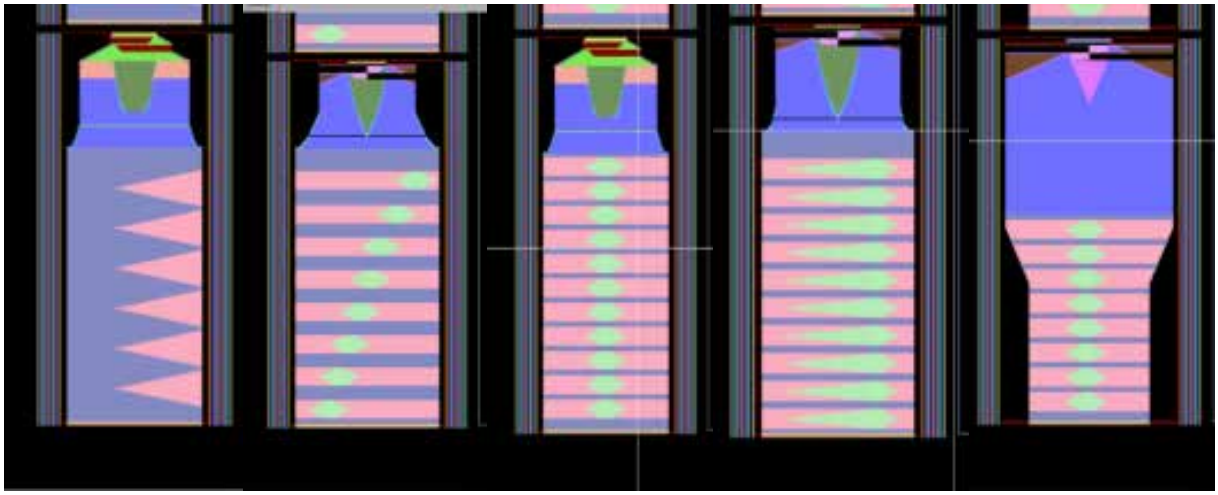

Figure 3: Five tunic designs, each with a different use of one of the two developed 'packages' (Smith 2013). Source: 'Knitpaint', Shima Seiki Manufacturing.

Figure 4. First of garments developed using the tunic pre-installed shape with added designer pacs (Smith 2013).

The garments shown are some of the results from using just two additional pacs, the wedge and the diamond wedge, on a basic tunic shape (Figure 4). Modifications were more distinct when used on both back and front of the garment, as seen in the first garment on the left, or when used in a vertical line through the centre of the garment, as seen in the last garment on the right. As already emphasised, it is not possible to predict what a knitted garment will look like when processed and knitted from the two-dimensional imagery in the compressed form. This is a format most closely resembling something that a designer would recognise. It is possible to move the design at this point to the Design System, but because the CAD software is not able to reconstruct the movement of stitches, or wales, it cannot represent this shaping visually in stitch structure form (Figure 5). Where wedges were placed on a standard tunic shape, the resultant garment is curved, but the stitch structure image remains symmetrical and rectangular in format.

Figure 5. Stitch structure of additional pacs in 'design' format and realised garment (Smith 2013). Source: 'Design', SDS-ONE Design, Shima Seiki Manufacturing.

There were a number of findings relating to shape modification and three-dimensional form building, uncovered from the first seven or eight garment developments. When a garment has differential forces applied to both front and back, an asymmetrical hemline with diagonal drapes folds through and around the body. This same garment, when seen lying flat, has such intensive movement that the forces twist and fold the body, displacing the neck and armhole openings on to a diagonal line. All of the garments had such intensive modifications, created through forces applied using diamond wedges through the front of the garment. Differentiated results were achieved by using different configuration formats, but all had hemline distortions. The modification of the hemlines differed from asymmetrical to symmetrical, depending on the degree of movement caused by forces created by the diamond wedges. Deformation was more exaggerated the further the inflective forces were placed away from the central vertical point of the garment. Further findings were that the depth and length of the wedges created a more or less defined fold, depending on the increase or decrease of intensities, which ran through and around the garment body. All garments had to be read as flat two-dimensional shapes. It was not until they were worn that intensities of movement could be seen acting and counteracting forces around a body, taking on a third dimension. These forces multiplied, folded and refolded, changing shape and formation which changed again when a body moved.

At this point it was realised that further pacs would need to be developed for similar movements to be accomplished within all of the other basic pre-installed garment programmes. For a sweater and a cardigan format, each pre-installed format would need separate pacs for the left, right or central wedge. This brought the number of pacs developed to nine. A technician developed all of these additional pacs; but once this was completed, it was possible to apply and work with these pacs independently, to create garments. As a designer, the more that was achieved and fed into a cycle of building design capacities through design lexicon memory, the more a designerly process was being developed and understood, intrinsic to the technological capabilities. Advancements were made with developing design parameters whilst also building up a praxis knowledge with the technical programme, Knitpaint, thus developing a greater understanding of the translation between the two-dimensional imagery and the three-dimensional realities of a garment. Further designs were completed using both the sweater and cardigan basic pre-installed programmes, with the pacs that had been developed added to them in a variety of configurations. The visual CAD imagery remains very similar in each garment configuration, but the three-dimensional form of the garment when knitted out differentiated with each iteration (Figure 6). It was only possible to gain a design knowledge of three-dimensional results through making, when working with this technology. Each garment incrementally grew from the previous garment, as did both technical and design outcome knowledge.

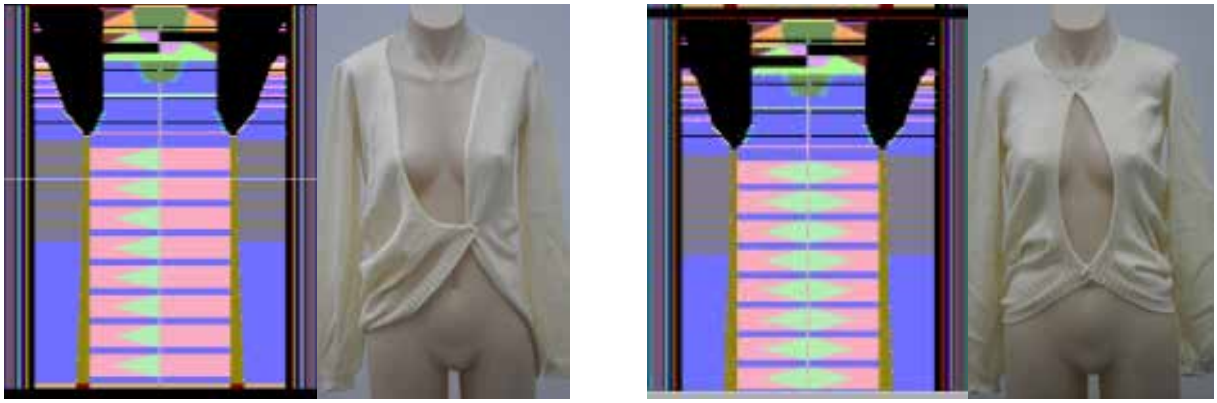

Figure 6. Comparison of two cardigan shapes on computer image (Smith 2013). Source: 'Knitpaint', SDS-ONE, Shima Seiki Manufacturing.

The imagery of the CAD system within Knitpaint remains very removed from the reality of the garment produced but, because the designer is working in an incremental way, each time a garment is produced they are able to interact with it through visual and touch sensory responses, the physicality of the garment. The garment's matter becomes folded into the development process, maintaining designer-design tactility, enabling a haptic response to findings as they emerge.

The collection is a swarm

The seamless knitwear technology is designed to produce replicated knitwear for mass-production, losing the quality of craft and the nuance of designed details within garments. Through the linear production processes, which are inherent within the design system, repetition of the same is generated, again losing the craft detail that differentiates one product from another via individuation.

Seamless knitting, through its very mode of production, challenges any simple binary division between interior and exterior. Its seamlessness enables interior to become exterior if garments are inverted, with little else other than the stitch structure changing from knit to purl. Its method of making in circular motion renders the joins invisible, therefore enabling the interior to be the exterior with minimal transformation of the final form of a garment. The usual knitted object has a defined inside and outside, as do most conventional textiles or textile objects. An inside manifests the connections of parts, revealing the manufacturing processes (Turney 2009). Seamless knitwear merges the inside with the outside just as the knitted stitch is formed by the yarn passing from the front to the back as it loops around itself to form the face and the reverse surfaces of the fabric simultaneously. The seamless garment when worn on a body becomes an exterior with the body interior. Due to seamlessness and merging of interior and exterior, when worn the garment capacities for forming/deforming the space between it and the body become realised without interruption.

Seamless garments, as with all textiles, may be thought of as resultant actions/reactions to forces of manufacture, which have been distributed throughout the garment in an intentional manner by a designer, plying with *interference* of construction techniques. The garment and the interior body are able to react with one another to redistribute the *fullness*, or highest intensive degrees, created by internal movement of fabric structures, distorting garments and nullifying standardised forms. This deforming of subject-space, through redistribution of exterior fabric around a body, creates garments that envelop the wearer in folds – drape, fold/unfold, form/re-form – constantly changing, actuality to virtuality and back again, touching potentiality (Massumi 2002). The intrinsic structure of the seamless garment and additional structural forces added by the designer through the registration of partial knitting pacs create internal movement of the knitted wales away from the parallel. This disturbance off-the-parallel intensifies the force of movement around a body when doubled and tripled, from double pacs being applied, or when forces collide from opposing sites of a body, complicating the exterior formations of the garment.

Figure 7. Movement of directional forces shown when added 'pacs' have been applied to standardised shapes (Smith 2013).

The resultant garments use a body as central core, and pivotal points on the body support the structure of the garment. Due to internal garment forces created by movement around the body, the garment deflects away from its *nature* – the 'natural' bodyline recreating an individualised three-dimensional form. The differential forces in each garment create singularities of design that, though machined, are not of a standardised shape. *They are singular though entirely replicable*. They move around a body, creating asymmetrical lines away from the parallel, course to wale lines creating organic forms. Each interpretation of a garment changes with its point of view. The distorting course to wale creates curvilinear shapes, inflective surfaces and, due to the absence of seams, enables free rotation. There is an affect; the sensation of an excess of fabric that drapes. Its sensate matter seems to form body-spacings peculiar to its garment flow, asymmetrical, fragile, and impermanent.

Drape and asymmetry are intensified through texture, the folds of matter enacted in linear stitch structures. Garments with twists and double twists create movement and multiple movements throughout their three dimensions. These movements distort the linear stitch structures away from the horizontal or the vertical, mimicking and emphasising the force of movement happening throughout the garment. The resultant collection is composed of singular garments of organic three-dimensional de/formations, challenging the standardised output normally created using seamless knitwear technology. This has been achieved by allowing the designer to become central to the design process, by reinstating a rhizomatic designer–fabric–garment assemblage, at odds with the Design System/Knitpaint arborescent hierarchy. A designer more familiar with body–garment–space assemblages has connected to the interior processes of designing that were always already there in the mechanical assemblages of Shima Seiki technology, but required a particular point of view in order to reveal the genuine modal essences of that technology. The designer has thus become enabled by the technology and not excluded from it.

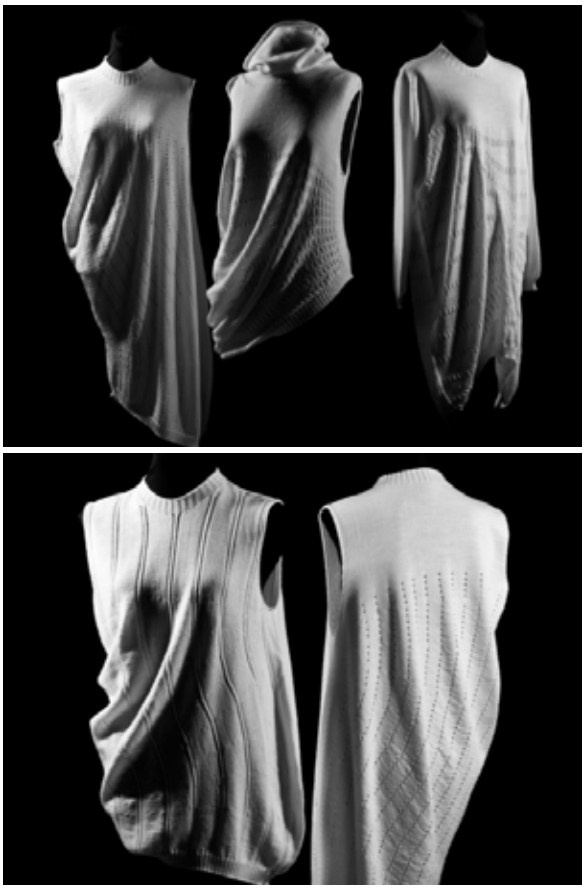

Figure 8. Final collection of three-dimensional garment forms with stitch structures emphasising directional flows (Smith 2013). Photo by E. Hughes.

The fragility of the garment collection's evolving singularity creates an 'encounter' with impermanence, evoking the temporality of its materiality, and fashion as an immanent becoming. This is not the wabi-sabi of the decayed or faded but of an irregularity and the transformational, indicating impermanence through the subtleties of formation, of fold/unfold. Memories of making are traced within the work, inflecting affective excess, thinking's inventing and a thing's functioning-motion through incorporeity. Material objects connect across their interiority/exteriority with an asymmetry and irregularity of structured surfaces, organic, intrinsic material forces, creating at times awkwardness of forms, irresolute and unresolvable, yet with intimate, understated trace-like structural veins. The time of a garment is encountered in another way, as it folds, unfolds and refolds.

References

Bergson, H. (1991) *Matter and Memory*, trans. N.M. Paul and W.S. Palmer. London: George Allen & Unwin Ltd.

Black, S. (2002) *Knitwear in Fashion*. London: Thames and Hudson.

Black, S. (2012) *Knitting: Fashion, Industry, Craft*. London: V&A Publishing.

Deleuze, G. (1991) *Bergsonism*, trans. H. Tomlinson. Brooklyn, NY: Zone Books.

Eckert, C. and Stacey, M. (1994) CAD systems and the division of labour in knitwear design. In: *Women, Work and Computerization: Breaking Old Boundaries – Building New Forms*, pp. 409–422.

Hunter, B. (2004–5) Complete garments: Evolution or revolution (Part III). *Knitting International*(December/January).

Inouye, C.S. (2008) *Evanescence and Form: An Introduction to Japanese Culture*. New York: Palgrave Macmillan.

Juniper, A. (2003) *Wabi Sabi: The Japanese Art of Impermanence*. Rutland, VT: Tuttle Publishing.

Massumi, B. (2002) *Parables for the Virtual: Movement, Affect, Sensation*. Durham, NC: Duke University Press.

Mowbray, J. and Spencer, D. (1995) The pursuit of WHOLEGARMENT production. *Knitting International*.

Power, J. (2007) Functional to fashionable: Knitwear's evolution throughout the last century and into the millenium. *Journal of Textile and Apparel Technology and Management* 5: 4.

Smith, A. (2013) Seamless knitwear: Singularities in design. AUT University, Auckland, New Zealand. Available at: http://hdl.handle.net/10292/5761.

Spencer, D. (2001) *Knitting Technology*. Lodon: Woodhead Publishing.

Turney, J. (2009) *The Culture of Knitting*. Oxford: Berg Publishers.