Towards the Posthuman: Materiality and process in the creation of stimulus-responsive jewellery objects

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Abstract

The idea of creating a jewellery organism that comes alive on the body has fascinated and inspired my research ever since learning about the potential inherent in smart materials almost ten years ago. While smart materials have been known to scientists for far longer (Huang et al., 2010), and have been used to great effect in engineering and aeronautic applications as actuators, their use in contemporary art and craft has been sporadic, most likely because of the challenges posed in processing and shaping them. With the increased prevalence of digital technologies in our everyday lives, the questions posed to the contemporary craft practitioner regarding the creation of a more refined interaction between the digitally enhanced object and its wearer have become progressively more prominent in the applied arts. Through examining the notion that human biology is a part of material culture, where the body can be shaped, customised or altered through surgical intervention and scientific innovation, my research explores how recent developments in material science and wearable technologies can be viewed as moving towards a future embracing the posthuman body, bridging the gap between craft practitioner and scientific discovery. Developing a holistic approach, whereby material experimentation and digital production processes are used to facilitate the development of aesthetically and biologically integrated wearable technologies, is the goal I strive towards attaining. More immediately however, I am challenging the perception of smart materials and their application within the field of contemporary jewellery in both an artistic and scientific context through proposing the development of symbiotic stimulus-reactive jewellery organisms.

Taking Jayne Wallace's provision for the amalgamation of technological enchantment and aesthetic beauty as a starting point, my research addresses aesthetic considerations alongside functionality. Thus developing material and technological solutions that constitute an integrated and functional yet unified part of the jewellery object as a whole. While previous projects have placed a strong emphasis on simply creating receptacles to accommodate electronic components within a wearable object, the possibilities offered by digital manufacturing technologies such as rapid-prototyping and computer aided design (CAD), have expanded the aesthetic vocabulary available to the practitioner.

Furthermore, the development and increasing availability of a range of stimulus-reactive smart materials, in addition to the progressive miniaturisation of electromechanical components, has turned the prospect of developing jewellery objects that appear to be responsive to their environment, yet depend closely on an interaction with the physiology of the wearer's body to stimulate these responses, from a distant imagining into a feasible goal.

Prototyping and Playful Practice

The concept of prototyping, despite being firmly established as an essential part of the concept development – visualisation – prototyping – testing cycle within fields such as product design and architecture and undergoing an increasing amount of critical investigation (Moggridge, 2007), is still not generally recognised as an integral part of the contemporary crafts. Within the context of disciplines such as fashion, ceramics and jewellery design, prototyping is still often referred to as making *test-pieces*, *samples* or *mock-ups*, and thus has received little analytical or critical attention as a process in its own right. In her investigation of design principles used with contemporary craft, Sarah Kettley successfully identifies the internalisation of a particular material or process achieved through visceral immersion through manipulation, handling, repeated exposure and drawing as one of the key factors in imbuing crafted objects with emotionally resonant qualities that transcend mere artistic and personal expression:

> *Craft has been described as being 'without design' […] It is continuous, rather than discreet in nature, and it is suggested that this is the root of the 'holistic' perception of craft. (Kettley, 2005)*

A similar approach to the process of creation is advocated by Soetsu Yanagi, a Japanese philosopher and founder of the Mingei (Folk Art) movement. While Yanagi largely opposes technological development and industrialised mass-manufacturing, he stipulates that the purest form of beauty possible in a crafted object is attained when the craftsman reaches an almost meditative state that is achieved through the complete immersion in his chosen medium. Eradicating the taint of his ego and personal ambition (Yanagi, 1989). Both approaches uphold an appreciation of the value of complete absorption in the process or material of a crafted object without further defining how this process might take place.

Some steps towards analysing and defining such processes of immersion in contemporary craft practice have been taken and are encompassed by the concept of playful practice. As Nina Lieberman states in her examination of playfulness and its relationship to creativity and imagination:

> *Among the personality characteristics of his art-wise subjects, Child (1965) found a capacity to escape momentarily from the unusual logical restraints of adulthood and the ability to take an interest in playful, imaginative and unusual aspects of things. […] The model here would suggest that, to the extent that the playful enters imagination and originality, it creates that suspense of tension, that psychological distancing required for the idea to form and to be produced. (Lieberman, 1977)*

As soon as playfulness is combined with prototyping a creative process of trial and error emerges that can yield innovative and sometimes unexpected results. This process is a key part of my artistic practice, and one of the main cornerstones of my research methodology.

Using design methods such as drawing, photo studies, collage, material experimentation, and CAD (Martin and Hanington, 2012), my research process consists of developing a series of prototypes as well as finished jewellery pieces and objects. With each of these prototypes my understanding of the material qualities and processes used increases until I am able to develop a personalised, original, visual language that transcends functional considerations and focuses on harmoniously integrating microelectronic components and smart materials into a jewellery object that is both aesthetically as well as functionally resolved. Through engaging in a holistic process of material immersion and experimentation, I am developing a body of work that encourages personal artistic expression while leaving space for serendipitous discovery. As Michael Schrage puts it:

> *The real value of a model or simulation may stem less from its ability to test a hypothesis than from its power to generate useful surprise. […] It holds equally true that chance favours the prepared prototype: models and simulations can and should be media to create and capture surprise and serendipity. (Schrage, 2000)*

The difficulties of applying such a methodology of playful interaction and experimentation to CAD modelling have been well documented and are the subject of much discussion. Makers without an intimate knowledge of coding languages and algorithmic computation often struggle to create object files that push the boundaries aesthetically whilst still fulfilling the many requirements that constitute feasibility for the three-dimensional printing process. Thus allowing the transition from an idea on the screen to a physical object. As Tavs Jorgensen points out:

> *While digital media has the potential to free craft practitioners to create beyond the physical constraints of his/her skills, there are still important elements of traditional craft practice which remain relevant and have yet to find a transition into new media. (Jorgensen, 2005)*

Solutions such as the *Tacitus Project* (Shillito et al., 2001) and the Cloud 9 software package (Shillito, 2014) strive to re-design the virtual workspace and the devices used to interact with it by enabling haptic feedback modelling. But investing in such technology represents a large financial risk for the individual designer-maker, as well as a serious time commitment to learn the software. Similarly, Jorgensen's use of the ShapeHandplus Motion Capture System to create flowing gestural forms (Jorgensen, 2007) is an unfeasible process for most craft practitioners as they lack access to the device.

There are aesthetic risks too when committing to such an approach. The Cloud 9 modelling environment enables its users to treat the virtual material being worked on like clay, pushing and pulling with the haptic Novint Falcon controller and delivering real-time tactile feedback. Through this, the Cloud 9 System emulates the process of interacting with physical materials through experimentation and creative *play*, despite still functioning within the parameters of a two dimensional virtual workspace.

This might seem like an ideal solution for those makers wishing to use CAD technologies in their making process while maintaining their ability to directly interact with the form they are developing. However, it is all too easy to produce forms that are aesthetically uniform, creating 'blobtecture' objects (Masterton, 2007) that are immediately recognisable as having been generated in this way.

In a similar vein, the digital 'cyberpunk' aesthetic created by more widely used programmes such as Rhinoceros 3D, AutoCAD and Solidworks has become instantly recognisable. Both of these aesthetic stereotypes can be attributed in part to the inherent difficulty of creating an object that contravenes

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geometries and design processes dictated by the computational logic of the individual programme used without delving into the unknown depths of grass-roots programming. In his research, silversmith and digital maker, Drummond Masterton, addresses this issue by painstakingly reviewing and manipulating individual lines of code within the CNC milling program he uses. While he admits that '[t]hese objects do not escape a CAD aesthetic any more than a hammered bowl escapes a hammered aesthetic,' (Masterton, 2007), Masterton's contemplative absorption in the minutiae of programming counteracts a tendency inherent in the process of CAD to rapidly work through multiple iterations of a digital design without questioning its aesthetic qualities. In this, Masterton comes close to Yanagi's ideal of meditative immersion, using the digital just as he would more traditional hand tools to play, reflect and experiment.

However, while these different approaches to create a less conventional methodology of digital creation are suited to the individuals who have engaged in developing them, I found that none of them suited the aesthetic I was striving to create in my own work. Taking inspiration from natural growth patterns such as those found in microscopic structures and fungi, my aim is to develop an approach to digital design that will allow for unpredictable and random manipulation of geometric structures. Most natural forms follow rhythms of growth dictated by underlying mathematical algorithms such as the Fibonacci sequence. It is in this aspect that CAD and nature intersect in a fortunate way, and the field of generative design, populated by mathematicians, architects and programmers turned crafts practitioners bears witness to this fact.

In combination with digital means of production, artists such as Neri Oxman (Oxman, 2010) have created some truly astounding pieces of digital art; beautiful in their regularity and perfection as well as ambitious in scale and material choice. Some CAD software even has the capability to mimic processes of natural growth through providing plugins that automatically generate algorithms according to user-specified parameters. An interesting example where this possibility has been placed in a commercial context is the Nervous System design studio (Rosenkrantz and Louis-Rosenberg, 2014). Their website not only sells finished jewellery based on cellular structures, but also allows users to design their own creations with the help of an interactive app, delivering real-time pricing and delivery estimates for various material choices. As Katie Bunnell points out:

> *These examples of customisation made possible through digital technologies represent the beginnings of a closer relationship between digital production and consumption that enables the creation of one-off designs from users' specification (Bunnell, 2004).*

Objects created in such a way often appear sterile and predictable in their geometric perfection. Computational modelling algorithms possess an inherent mathematical precision that is anathema to the natural structures they are trying to evoke. While these algorithms play an important part in underlying cell formation, environmental factors such as growth space, light or lack thereof and physical trauma influence random mutations within cell growth that are hard to predict and even harder to emulate via computational means.

There are form generation tools such as the Grasshopper plugin for Rhino that enable users without scripting skills to program generative algorithms through a graphic led user interface, but none that are sophisticated enough in their randomisation of patterns to truly reflect nature's propensity for arbitrary mutation. Each of the modelling programs discussed in this section have their own limitations. Truly achieve the sense of harmonious imperfection that makes natural structures so compelling despite their geometric origins, I am currently experimenting with combining different programs and exploiting their strengths and weaknesses in different areas of design.

Coming from a jewellery design background, the first program I was introduced to was Rhinoceros 3D. Based on the Non-Uniform Rational B-Spline (NURBS) mathematical model, Rhino, as it is commonly referred to, allows the skilled user to create and manipulate a large variety of objects consisting of surfaces, curves and control points. For the novice, an advantage of Rhino is that it is possible to create complex and mathematically precise objects by joining, copying, pasting and adjusting a series of pre-set three-dimensional solids, or to create new solids from two dimensional curves. Once a solid has been created it can then be exploded into its component parts (surfaces, curves and points), which in turn allows for the direct adjustment of these components by the more experienced user in order to create shapes that diverge from the known matrices before re-joining them.

Finally, the NURBS solids created in this way are translated into stereolithographic (STL) files that describe the surface geometry of the created object in triangular segments in a process known as meshing. The resulting triangulated mesh represents the final output Rhino is capable of producing as the program has only a very limited capacity to work with mesh objects directly.

The first object I created for my body of research using Rhino is the stand for the Clathrus Ring (Image 1). Inspired by the geometric lattice of the Clathrus mushroom, the structure of the stand was constructed by fusing individual surfaces in modified hexagonal patterns. This method of creating an object, while affording a maximum degree of control over the final outcome, is extremely labour intensive and also means that objects cannot be easily manipulated.

Additionally, this approach is much more suited to the creation of geometric surfaces than anything requiring a more organic aesthetic. Rhino's user

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Image 1

Image 2

Image 3

Image 1: *Clathrus Ring* and Stand, Kathy Vones (2012)

Image 2: *Mycelia Brooch* and Stand, Kathy Vones (2012)

Image 3: Shape Experiments in various materials, Kathy Vones (2012-14)

interface is not particularly intuitive, and often the adjustment or building of individual surfaces from curves creates problems with the underlying mathematical integrity of the geometry of an object. A reliance on extreme precision means that often objects created in a more unconventional fashion that do not follow protocols of methodological sequences established as 'the right way of doing things' within Rhino, can become riddled with bad edges and inverted surfaces, which cause problems during the 3D printing process. Fixing such objects can be a long and drawn-out process often requiring the rebuilding of troublesome areas of a model, and might not be at all possible on occasion.

Consequently, and in line with the idea of a more playful approach to CAD modelling, I have developed a methodology which enables me to build complex geometric structures in Rhino and export them as polygonal meshes instead of NURBS or surface-based objects. These are subsequently imported into a mesh based CAD modelling program where they can be shaped, deformed, joined and manipulated freely.

One of the first pieces I created using this technique was a stand for the Mycelia Brooch (Image 2), which echoes the structure of the brooch as well as the irregular bubble texture of its central silicone and mineral elements. Other shape experiments (Image 3) are much more unpredictable in their geometric realisation than similar objects would be using computational modelling, reflecting the direct involvement of the artists' hand in their creation. Taking these shape experiments forward by combining them with smart materials and integrating them into an aesthetically cohesive jewellery object is the next step in my research process.

Towards a New Materiality

Since the first institutional materials library in the UK opened at the Royal College of Art in 1974 (Wilkes, 2011), the increasing desire by designers, visual artists and materials enthusiasts to explore a wide range of both commercially available and highly experimental materials in an open, collaborative environment has given rise to the exponential growth of materials libraries over the last decade. Within the UK alone, nine materials libraries currently operate, each with different foci and access parameters, ranging from those based at academic institutions to fee-paying commercial consultancy ventures. While some libraries select materials by focusing on a particular discipline, such as architecture, interior design or the construction industries, others specialise in rare, laboratory-grade materials. Most commercial materials libraries also have extensive searchable online databases, whilst others exist only online and have no physical site to examine materials first hand.

However, while the agenda of sharing knowledge and creating connections between materials scientists, the materials industry, designers and artists is a worthwhile one that should be encouraged, particularly at a time when collaborations between the arts and sciences are essential for the development of new cross-disciplinary approaches, there are still significant barriers in place when it comes to creating such exchanges. Advocates of materials libraries such as Mark Miodownik of the Institute of Making, London, praise their ability to encourage scientists to think about the senso-aesthetic properties of materials rather than their functionality by consulting artists, designers and crafts practitioners, whose main focus arguably lies in identifying how users connect with materials on a more intuitive level:

> *Characteristics such as smell and feel are almost impossible to capture in simple numbers, [Miodownik] noted, and many modern products show evidence of the fact that these properties were*

ignored during their design. The only way that people can gain an understanding of these other material properties, suggested Miodownik, was by experiencing the materials directly – touching them, manipulating and interacting with them in different ways. (Ward, 2008)

Miodownik's plea applies to material scientists and arts practitioners alike – with one group needing to explore ways of designing materials that contain optimum functionality while also taking into account senso-aesthetic properties. The other group engaging with how such materials could be used sensitively in designing an object with maximum functionality whose tactile and aesthetic qualities capture the imagination of the end user.

The constraints currently faced by materials libraries in achieving such a goal are still significant. While the idea of the materials library as a collection of unusual materials to be made available to arts practitioners, researchers, and scientists alike may have been around for thirty-nine years, the serious progression of a strategic agenda in terms of building such collections and making them available to a larger audience is a fairly recent development and has only really gained momentum since the beginning of the twenty first century. Even those materials libraries that have been established over the last decade, both in academic institutions and as commercial ventures, are limited in the scope of their expertise. As Miodownik points out:

They serve very specific design communities, their materials collections are extremely limited, they only deal with commercial materials, but most importantly, they are almost completely dissociated from the materials-science community. (Miodownik, 2009)

Additionally, the ties between industrial suppliers of materials and materials libraries are tentative at best. Many suppliers are reluctant to provide experimental materials in quantities small or large enough to be useful to arts practitioners in their research and development, or indeed at all. In her conversations with material librarians, Sarah Wilkes extrapolates that:

In the eyes of many involved in materials education, concerns over corporate secrecy and ownership on the part of materials producers are a hindrance to both creativity and technological progress. (Wilkes, 2011)

The questions of intellectual property and pending patent applications loom large during such exchanges between supplier and practitioner, and frequently a satisfactory conclusion cannot be reached. While some of the most interesting materials represented in materials libraries are often in a pre-commercial stage of development, suppliers are worried about providing such materials to researchers before potential revenue-generating avenues have been exploited. This quickly turns into a catch twenty-two situation, with many materials never reaching financial viability at all due to their lack of practical applications and thus commercial demand. Often such demand might have been created if designers and arts practitioners had been encouraged to experiment with these materials and thus potentially discovered novel and previously unanticipated ways of using them. To recognise the potential of such mutually beneficial relationships, a liaison between industrial suppliers and creative practitioners, experienced in dealing with the concerns of either party would be necessary; something a lot of materials libraries are struggling to provide as of yet.

As part of my research, I have visited three materials libraries so far: the Materia Inspiration Centre in Amsterdam, the Innovathéque FCBA and the Materió Materials Resource Centre, both of which are located in Paris. These field visits have been valuable and enlightening, with materials having come to my attention that might not otherwise have. However, they have also revealed inherent difficulties faced by individual craft practitioners and artists looking to use materials libraries for their practice – in particular accessibility and utility of the information acquired.

While open-access libraries such as the Materia Inspiration Centre, now unfortunately closed permanently, operate on a sponsorship model and rely on contributions from manufacturers to display new materials in their physical and online libraries, most other materials libraries not operating under the umbrella of an academic institution currently operate on an annual or monthly subscription based-model. As can be seen in the case of Materia, the sponsorship model is highly dependent on sustaining support from materials manufacturers and industry clients, who in turn follow the dictates of wider economic circumstances. A recent downturn in the construction industry and its associated branches has meant that demand for the services of Materia, and thus its financial support, has waned (Materia, 2013). The decision was taken to close the physical site in Amsterdam. Materia's collections are still available for viewing through travelling exhibitions at trade shows, and the online database remains fully operational. For the individual practitioner seeking tactile access to materials, this is still a grave loss.

On the other hand, both the Innovathéque FCBA and the Materió Materials Resource Centre operate on a subscription based model. In an interview with Brice Tual, materials consultant at the Innovathéque FCBA, I discovered that one of the main motivations for using this model is to enable a more critical and independent criteria-based selection system for the inclusion of new materials (Vones, 2014).

Tual states that the Innovathéque FCBA selection committee, consisting of up to six members from a variety of backgrounds, meets four times a year to whittle a pre-selection of over 2000 materials down to a maximum of 250 for inclusion in the library per year.

Selection criteria are stringent and immediately exclude any materials without safety data and technical information, effectively shutting the door on materials that are still at a lab-stage of development. While this is entirely understandable for a commercial venture aimed mainly at sectors such as product design, fashion design, architecture, furniture design and ecological design who use these libraries as a time-saving shortcut in their product development cycle, the scope of the materials on offer is immediately curtailed. Furthermore, the library's role as mediator between designer and supplier ends after the first introductory phone call; all negotiations that follow are to be conducted entirely by the clients themselves.

Additionally, there is no established system of classification for the materials kept in materials libraries, and with each library having devised its own way of displaying, storing and cataloguing their collections it is virtually impossible to tell whether any particular library might be of use to the individual practitioner without extended visits to the physical sites or online databases. The increasingly rapid development of new materials often renders holdings obsolete and the issue of shelf space means that legacy materials are frequently discarded or consigned to inaccessible storage indefinitely.

The relatively expensive annual subscription packages offered by materials libraries, affordable to commercial clients and governmental bodies, are financially overwhelming for individual craft practitioners and self-employed designers. As a result, only very few have access to these resources. Materials libraries based within educational establishments, such as the Institute of Making at Kings' College London, seek solutions for individual makers to have improved access to their collections by arranging monthly open-days, masterclasses and running a MakeSpace. But these are very recent developments and the classes and facilities are currently only open to staff, students and researchers based at the institution. It seems that for the adventurous craft practitioner without an academic connection it would be more beneficial to engage in the initial research process themselves by visiting materials expositions, conducting internet research and contacting suppliers directly.

Exploring the Future: Smart materials

I initially became aware of a group of smart materials known as Thermochromics through a presentation given by Dr. Sara Robertson (Robertson, 2011), at the CIMTEC 2012 conference in Montecatini Terme, Italy, exploring the potential of temperature-sensitive thermochromic dyes and heat-profiling circuits in textile design. Intrigued by their ability as a smart material to respond directly to a change in body temperature through colour change, I began to explore their potential in combination with the three dimensional silicone shapes I had been developing.

Thermochromics are commonly available as either dye slurry or in powdered pigment form, and fall into the two main categories of leuco or liquid crystal thermochromics. Either variety is available in a range of colours and with different temperature change points that display a visible colour change with an increase or decrease in exposure temperature. Leuco dyes change from pigmented to colourless when a hot or cold source is applied, which depends on their change temperature, and assumes pigmentation again as soon as the source of temperature change is removed. Analogue Liquid Crystal dyes cycle through a set of colours that correspond to the temperature they are exposed to. The most recognisable form being the 'peacock' colour pallet ranging from red through yellow, green and deepening shades of blue. After a certain peak temperature is reached towards the dark blue spectrum, usually about 20 degrees above activation temperature, visibility of the pigment ceases. It only returns in the cooling phase when it cycles through the previous colour shifts in reverse until it once more falls below its activation temperature. Digital Liquid Crystal technology, in which the pigment appears to be either in an *on* or an *off* state according to the temperature it is exposed to, has also recently become available. The colour change reactions of thermochromic dye systems are available as reversible and irreversible types. However, as one of the definitive conditions of smart materials is full reversibility, only the former type can be categorised as such and is of interest to me in this respect.

There are a variety of practical and industrial applications for thermochromic pigments, dyes and paints. One of the most well known is the inclusion of

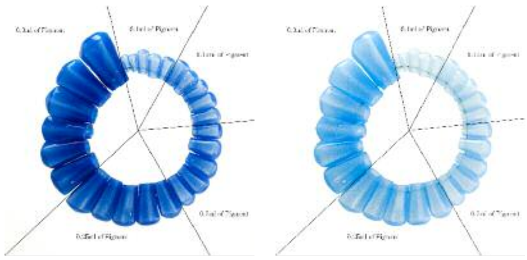

Image 4 & 5

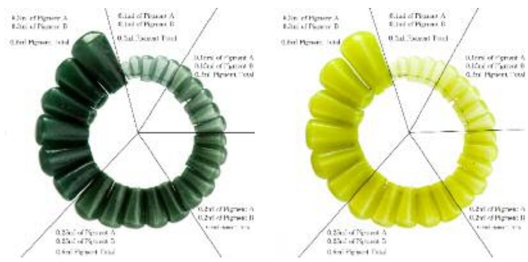

Image 6 & 7

Image 8

Image 4&5: Example of a single pigment test: Blue 27˚C in its unchanged and changed state.

Image 6&7: Example of a dual pigment test: Blue 27˚C and Yellow 38˚C in its unchanged and changed state.

Image 8: Example of the progressive stages of change in a dual pigment sample of Magenta 41˚C and Yellow 38˚C.

Image 9

Image 10

Image 11

Image 12

Image 9: *Xylaria Brooch* in its changed state, Kathy Vones (2013).

Image 10: *Cocoon Necklace* in its changed state, Kathy Vones (2013).

Image 11: Sample of thermochromic silicone fabric in its changed state, Vones & Robertson (2013).

Image 12: Segment of thermochromic colon model, Vones & Pakleppa (2013).

liquid crystal technology in forehead thermometers. Each degree of measured body temperature is assigned a corresponding colour. Similarly, Leuco dyes are widely used in fuel assemblies to test combustion engines and as friction markers in engineering, affecting an irreversible colour change when heated and thus signalling a state change of the monitored component (Robertson, 2011).

My research currently focuses on exploring the potential of layering leuco and liquid crystal pigments in silicone to explore the interplay of colours created by different colour and temperature combinations. I have adopted a rigorous testing protocol for these experiments, starting with four base pigments in different colours and each with a different change temperature (Blue 27˚C, Yellow 38˚C, Magenta 41˚C, and Red 47˚C). Each batch of samples is made using the same process, requiring 16.5 g of mixed silicone for a full set of 25 with one extra shape as a spare. An initial set of shapes of each single colour was prepared, starting with 0.1 ml of pigment and adding 0.05 ml of pigment every five shapes (Images 4 & 5).

Next, two pigments were combined in a single mix, starting with 0.1ml of each colour (a total of 0.2 ml) and adding 0.05 ml of each colour (a total of 0.1 ml) every five shapes. The resulting colours were then evaluated for hue, transparency and strength of pigmentation in both their changed and unchanged states. In their unchanged state, pigmentation strength is greatest in the final segment of each colour, with saturation levels nearing opacity, and weakest in the first segment, creating a translucent finish. Translucence yields to opacity at around 0.3 ml of added pigment. This result was predicted and corresponds to expectations formed from my past research in combining artists pigment with silicone.

The resulting colours of the combination samples follow the general rules for colour mixing as demonstrated on a colour wheel, and the resulting hues range from slightly disappointing to very pleasing, although this is arguably a matter of taste and artistic intent. With the application of heat, the samples go through a variety of colour changes. In their first changed state the lower temperature colour fades and reveals the underlying higher temperature pigment. The samples appear as a lighter version of their unchanged colour at this stage, with some combinations such as blue and yellow displaying a very distinctive change, while others such as magenta and yellow displaying a more subtle outcome (Images 6 & 7). If heated again, the second pigment fades and reveals a milky base colour with the dominant pigment in evidence as a pastel shade (Image 8). It is possible to further modify the colour response by introducing a permanent base shade consisting of artist or special effects pigments to the mixture. I am currently conducting tests to exploit the aesthetic possibilities inherent in this suggestion.

Conclusion: Towards a posthuman future?

Through conducting extensive materials research, shape explorations and colour experimentation, I have created jewellery objects containing thermochromic silicone in conjunction with 3-D printed structures that employ both traditional and modern jewellery making techniques such as photo etching and laserwelding. The resulting experimental pieces transform as they are being worn and respond intimately to temperature changes in both the environment and the human body. While the *Xylaria Brooch* (Image 9) uses leuco dyes to affect a subtle change in colour from orange to deep raspberry pink when reaching an environmental temperature of around 38˚C, the *Cocoon Necklace* (Image 10) also incorporates 3-D printed shapes coated in liquid crystal pigments that begin their transformation at around 25˚C, evoking the colours of a peacock's feathers. Collaborations with textile artist and researcher Dr. Sara Robertson (Image 11) to develop a process of creating translucent thermochromic silicone fabrics, and medical engineering researcher Markus Pakleppa (Image 12) to fabricate a temperature reactive scale model of a human colon to aid cancer patients in visualising the internal workings of their bodies, have enriched and guided my research process.

Potential practical applications of my jewellery objects exist in the areas of human–computer interaction, transplant technology, medically assistive objects, identity management and artificial body modification including prosthetics, where such symbiotic jewellery organisms could be used to develop visually engaging yet multifunctional enhancements of the body. Moving towards a future in which technology could become permanently integrated into the complex systems of the posthuman body I am intrigued by the possibilities and challenges facing the contemporary jeweller in advancing the debate surrounding the posthuman and interactive adornment. The intersection between technological refinement, the exploration of smart materials and new manufacturing technologies, as well as the development of an aesthetic expression that supersedes ideas of mere gadgetry, is a challenge in this area of research and one which I am in the process of addressing with my contribution to the field.

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