The Material Question:

Innovations in Textile Applications

A Critical & Historical Studies Masters Dissertation

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Question

1.1. The Materiality of Textiles

Objects appeal to us in three ways: by their visceral aesthetics, their behavioural functions, and the reflection of how these latter qualities work together. The aesthetics of an object are important in providing the surface impression; the expectation of its function and the sense of its value. These visual and tactile characteristics are fluid, and change with opinion and fashion. The functions of an object are often considered a more constant characteristic, but these can similarly change with society, as the object is forced into providing new applications; a chair is not only a chair, it can also be used as a ladder very effectively.

The aesthetic and functional qualities of an object are related to the materials it is made from and the processes which are used, and together make up its materiality. The materiality of an object provides the emotional connection a user develops with an object; the expectations they have of its performance and the associations they make with its appearance. These associations often place materials in stereotypical applications in user's minds. The use of a material in an unconventional setting can confuse the viewer, who can then make judgements about its appearance and capabilities based on their limited knowledge.

Textiles are a material which suffer this stigma. Having been used in conventional fashion and furnishings for thousands of years, the benefits which modern technology have made possible have been neglected. The use of advanced materials with the traditional textile processes and craft skills can enable textiles to create new functionality and visual appeal for all types of products and applications.

Textiles can provide many unique properties to a material and structure and the application of advanced materials within these traditional craft techniques can further improve these qualities. It can be possible for innovative and exciting products to be created through imaginative designer experimentation and open consumer attitudes.

The question is how can these benefits of traditional textiles be applied to new products to create innovative aesthetics and functional designs?

2.

Matter

2.1. The Materiality of Objects

The materiality of an object is an all encompassing description of its properties. This may involve its performance, technicality, appearance and physicality and, particularly relevant here, the perception of it as an object in the user's view. A product's materiality is the experience it gives to the user, and the ultimate aim of its design; *"products are sold on the basis of the feeling they evoke"* [1].

All products provide sensory experiences for the users, whether it be visually, aurally or tactilely. Through this experience a material connection is made with the object; the structure, texture, relief, temperature, weight is all communicated through the material of the object, creating what has been coined the material's *"emotional value"*[1].

Norman analyses this effect of the material on the way people interact with an object, and has dubbed the personalities gained by materials and objects the 'psychology of materials'. This psychological investigation into the way materials affect our opinion of objects highlights how, along with the actual physical properties of an object, we also perceive certain other properties relating to our associations of the materials used:

> *"Glass is for seeing through and breaking. Wood is normally used for solidity, opacity, support or carving*."[2]
> *"What matters is the history of interaction, the associations that people have with the objects, and the memories they evoke"*[3]

We associate materials with a narrow range of physical characteristics due to the conventional uses of them in our surroundings.

Manzini expands the notion of material connection. He explains the knowledge we develop through our experiences of materials by simply depicting the actions of a child throwing a ball against a wall:

> *"A child is playing with a ball – he tosses it against a wall, the ball executes a trajectory, bounces back, and the child catches it with a sudden lunge. A succession of ordinary actions that nevertheless presuppose – each time they occur – a remarkable heritage of experience, both personal and collective: experience of the qualities of material, of the laws of motion, of the transformations of energy, of the effects of fields of force."* [4]

Through repetitive experiences with materials we develop an instinctive reaction to the material's qualities and capabilities; the memory of our interactions with a certain object creates a deep knowledge of the qualities related to that material. This experience of materials is vital in expanding our knowledge of the broad range of the

[1] Ramakers, Renny, *Droog Design Less + More*, Rotterdam: 010 Uitgeverij, 2002
[2] Norman, Donald A. 'The Psychopathology of Everyday Things' in *The Design of Everyday Things*, New York: Basic Books, 1988
[3] Norman, Donald A. 'The Meaning of Things' in *Emotional Design*, New York: Basic Books, 1988
[4] Manzini, Ezio, 'Paths of Experience' in *The Material of Invention,* Milan: Arcadia Srl, 1986

characteristics in materials, but it can also unintentionally hinder our experimentation. Do our associations of materials with certain properties stigmatise those materials, affecting how they are used?

2.2. The Multiplicity of Materiality

The fact that we may have an association of a material with one certain use does not mean that the material can not be used in a different application in order to create a completely different sensorial experience. Antonelli describes materials as not fixed to a single appearance or function. Materials can be flexible in both their aesthetic and technical qualities, and deceptive to the user. Modern materials and processes provide *"multifaceted manifestations"* [5] to the experiences of the original material and the range of applications possible; the truth that materials once conveyed is no longer an absolute or unique concept.

It is not only our experiences which define a material in our knowledge. The function that it serves in an object also creates an association of the use of a material. Graves-Brown disputes this connection between the object's function and its material, however[6]. He argues that the form of an object is related to the material shape, and that the function is related to the object's specific use, the two of which are not necessarily linked. The 'specific use' of an object is an interesting phrase to define, from both a functional and material perspective. The functionalist view defines the function of an object to be *"part of the society and culture in which it exists"*; as society and culture changes over time, therefore, the objects' function can change too. Preston[7] discusses how the material of an object can also change the use of an object; the *"additional accidental"* functions provided by the multiplicity of a material's properties can provide other functions originally unintended by the designer, e.g. an old tyre used as a swing, or a spoon used as a musical instrument. As well as altering the function of the object, these accidental functions change the emotional value of the material used in the object and our perception of the object itself. The changed perception of the object and material can create an entirely new life for the product through the flexibility of the properties of the material, e.g. the new use of pipe cleaners as a craft medium.

The functionality as well as the materiality of objects designed throughout history evolves as much with user selection as it does with technology. Objects which have been around for many centuries can develop a familiarity, and so any step away from traditional material and form applications can be jarring. The introduction of Modernist architecture in the early 20th century was found by the public to be stark and de-humanised, but the glass, concrete and steel which formed the main construction of these buildings, have established themselves as core materials in

[5] Antonelli, Paola, *Mutant Materials in Contemporary Design,* New York: Museum of Modern Art, NY, 1995

[6] Graves-Brown, P Paul, 'Introduction' in *Matter, Materiality and Modern Culture,* ed. P Paul Graves-Brown, London and New York: Routledge, 2000

[7] Preston, Beth, 'Function of things: A philosophical perspective on material culture' in *Matter, Materiality and Modern Culture,* ed. P Paul Graves-Brown, London and New York: Routledge, 2000

architectural design today. Berylerian[8] discusses how the acceptance of these new materials into a set of conventional design resources allows designers to both work with and rebel against tradition:

> *'this scenario, which created 'default' materials, allowed two completely separate paths to emerge between those architects who embraced the new visual style and who chose to bring novel materials to it, and those who explored the amazing range and versatility of the limited set of material options.'*

The inclusion of glass and steel into current architectural design is but one example of the evolution of the public acceptance of new materials in traditional applications. However, profound changes in lifestyle do not occur overnight; the use of a contemporary material must be flexible, non-invasive and sensitive to the materials currently used. Successful innovations in materials have been where old and new materials and technologies have been combined, e.g. the combination of the technical and aesthetic properties of ceramics in kitchen stove tops. However, new material innovation can be combined with the old function of an object to create a new personality for the product only if the associations of the materials are abandoned. As Ashby insightfully says[9]:

> *"traditional uses of materials carry associations – a creative step is needed to use familiar materials in an unfamiliar way"*

It is the designer's responsibility to overcome this historical association of materials with functions and objects. The question is can the stigma of material usage be lessened in order to allow freer successful creativity and experimentation? Can our perceptions of materials develop as well as their technical and aesthetic qualities?

2.3. The Material Choice

Our knowledge of objects and the qualities endowed in them by materials has evolved categories and names into which the material quality or experience are placed. However, the multiplicity of functions of a material has made definition of these categories difficult. According to Manzini[10] a material is a *"system capable of performance"*; the material is defined by what it does not what it is.

What materials 'can do' has advanced dramatically over the last few centuries. Artificial material development has sped up the natural development of material properties considerably. The desire to manipulate materials into any conceived shape has pushed both the fields of technology and design to create more advanced and innovative materials and processes. The new technologies provided by new materials and processes can create a whole array of new products which are lighter weight, lower cost, longer life, and have new functionality, less eco impact, and more visual

[8] Berylerian, George. M, 'Material Matters' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997
[9] Ashby, Mike, Johnson, Kara, *Materials and Design: The Art and Science of Material Selection in Product Design,* London: Butterworth-Heineman, 2002
[10] Manzini, Ezio, 'Paths of Experience' in *The Material of Invention,* Milan: Arcadia Srl, 1986

and tactile appeal. Materials can change both the functionality and personality of a product instantly:

> *"By simply changing the material of virtually any product, without altering any other aspect of its design, one can change it from a commodity product in to luxury goods (or vice versa)."*[11]

Scientific and engineering advancements in materials have enabled materials to become a functioning structure in themselves. Manzini[12] identifies how *"traditionally a material was thought of as an elementary system whose task was to give structure to a more complex system"*; that the geometry of the object, and not the constituent material, was designed to give it functional performance. Now, however, materials can perform functions themselves; either providing a stiffening structure to an object, or adding to the aesthetic value of the product.

The engineering drive of material development involves the improvement of qualitative (and calculable) properties, for example how much load the material can carry, what temperatures it can work in, how well it ages. The experimentation of materials in terms of the aesthetic value it can give an object, however, is a much more abstract and sensorial practice traditionally experienced by craftsmen. Ashby[13] describes the aesthetics of a object as capturing *"the sensory attributes of a material"*. It is these sensations which the user experiences when interacting with the object that designers try to provoke and manipulate; the users experience of a product is 'designed' by understanding the effects of the material. Ashby[14] depicts the material's character to be *"hidden in a material before it is made into a recognizable form"*; it is this character that the designer must recognise.
The true knowledge of a material includes both the scientific properties which enable a material to perform the required functions, and the aesthetic qualities which serve to generate the appropriate sensations in the user. An engineer understands the former of these two areas of knowledge, and a craftsman the latter; a designer must understand both. Antonelli[15] notes how advanced materials are invented to meet practical needs. Advances in science and technology provide innovative materials capable of new improved functions. It is the introduction of these new materials into normal consumer products that encourages their acceptance by the public and the identification of new applications which extends further technical development.

The successful integration of new materials into unfamiliar applications needs both the development of intelligent and sensitive products from designers and the open-minded acceptance of new experiences from consumers. The question is, can certain materials escape from the stigma developed around their applications and capabilities to create products with innovative functions and exciting new personalities?

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[11] Berylerian, George. M, 'Material Matters' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997
[12] Manzini, Ezio, 'Paths of Matter' in *The Material of Invention,* Milan: Arcadia Srl, 1986
[13] Ashby, Mike, Johnson, Kara, 'Factors Affecting Material Selection' in *Materials and Design: The Art and Science of Material Selection in Product Design,* London: Butterworth-Heineman, 2002
[14] Ashby, Mike, Johnson, Kara, 'Design and Designing' in *Materials and Design: The Art and Science of Material Selection in Product Design,* London: Butterworth-Heineman, 2002
[15] Antonelli, Paola, *Mutant Materials in Contemporary Design,* New York: Museum of Modern Art, NY, 1995

3.

Material

3.1. Introduction to Textiles

Textiles are a material with this stigma. Their long historical applications in fashion and furnishings have led the public to accept the use of textiles in these everyday applications. The words fabric and cloth have become synonymous with textile, the individual definitions becoming almost inconsequential. But this general amalgamation of definitions is far from the truth. A textile, a flexible material comprised of a woven network of natural or artificial fibres[16], differs greatly from the definition of a fabric, a material made through weaving, knitting, crocheting or bonding, and from that of a cloth, a finished piece of fabric that can be constructed into a secondary object. These three words, synonymous in the general public view, can individually describe a plethora of technical, aesthetic and tactile qualities from which innovative and inventive applications can be derived. But has this mergence of terms affected our creativity in thinking? Has the ignorance of the individuality of the three terms - textile, fabric and cloth - prevented experimentation with textile processes and applications?

Ingold[17] describes this difference between textiles and cloth using the example of a woven basket. He identifies how a basket, although woven using the same method as any cloth, is not considered a textile. Despite their similarities in creation, a piece of cloth and a basket have extremely varying properties. Woven cloth, although a finished piece from the weaver's eyes, is a constituent material in the designer's eyes; it is a raw material, yet to be moulded into a final form. It needs a secondary process to create structure and shape. A basket on the other hand is a finished product; the material and structure of the form are created simultaneously. The textile process forms the finished object. It is this transference of thinking which Ingold encourages; from the conventional consideration of a textile to be a cloth with which to subsequently add form, to a view of a textile as a concurrent material and structural production process from which whole objects are created.

Ingold not only discusses the importance of accepting the ability of the textile process to create more than just a flat cloth, he also considers the need to understand textiles as a material in itself, away from any associations past historical applications may impart, and appreciate the fundamental properties they can provide:

> *"We need to overcome the conventional understandings of textile applications"*[17]

Knapton understands these fundamental properties that textiles can provide, and through this understanding explains why textiles have been particularly suited to an application in clothing:

> *"The fundamental property of a textile is its ability to alter its shape (deform, bend and twist) and consequently fit the human form"* [18]

[16] http://en.wikipedia.org/wiki/Textile (15/05/2008)
[17] Ingold, Tim, 'Making Culture and Weaving the World' in *Matter, Materiality and Modern Culture,* ed. P Paul Graves-Brown, London and New York: Routledge, 2000
[18] Knapton, J.J.F, 'The Engineering of Knitted Fabrics for Industrial Application' in *The Design of Textiles for Industrial Applications*, Great Britain: The Textile Institute and Contributors, 1997

However, he also understands that *"the same properties of textile material can equally well be used for a variety of other requirements"*[18]. The flexibility and tailorability of textiles have proved over the centuries to be ideal for providing both the functional and aesthetic demands of clothing design; both fitting the curves of the human form and producing a vast range of colours, patterns and textures. These properties of textiles, which prove so useful in clothing design, are applicable in many other areas of design, however, and should not be isolated to the application of clothing alone.

3.2. Technical Textiles

The properties of textiles have long been recognised in world of engineering; from the lightweight skin of the Wright brothers' first aircraft to the composite shells of Formula 1 racing cars. In these high performance applications, the properties demanded from the materials used prioritise function over aesthetic. The materials need to be stronger, lighter, tougher, to push the meticulously engineered designs further into the realms of possibility. As mentioned earlier, engineering is concerned with the qualitative and calculable properties of a material; an engineer will know the exact properties of the ideal material for his design, and he therefore demands materials to be perfectly tailored to the properties required. He will turn to material science to achieve this.

The tailoring of material properties has been experimented with for many centuries; from the combination of different woods to achieve a stronger material in several directions (plywood) to the introduction of woven meshes of fibres solidified in a matrix of resin to make strong curved structures (carbon fibre reinforced plastics). Composites are the combination of two or more materials to harness all of the constituent properties. Modern day composite materials such as glass and carbon fibres have been around since the 1950's, but the form which is most recognised today is the woven mats of carbon fibre, used extensively in the automotive and aeronautical industries. Here the benefits of textiles have been recognised. Through the ability of woven cloth to flex and shape around a curved form, many complex shapes have been able to be produced from the strong carbon fibres that make up the warp and weft of the material.

The flexibility and complex shape forming properties of textiles, vital to their application in fashion and which have now also found use in other engineering applications, are features of textiles inherent in the material from the weaving process. The structure of a fabric created by weaving is simply an orthogonal lattice of intertwined yarns, termed the warp and the weft. The simplicity of this material production process, while creating in itself a whole array of functional material qualities, allows many variations within the process, therefore creating the potential for a huge range of material qualities and features. As discussed by Dent[19], this potential for the expansion of material properties from a simple production process is enabling textiles to provide innovative design solutions.

[19] Dent, Andrew, 'Material Overviews' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997

"The build up of individual flexible filaments into a warp and a weft enables any abrasion, tensile or crushing to be accommodated by the filaments, dissipating the effect on any single filament. As such, woven fabrics are a superbly simple and effective system and continue to be at the forefront of materials innovation."

The innovation in weaving technologies allows the creation of new textures and patterns for textiles for fashion, but also enables more precise high performance qualities to be designed for. Like the creation of a textile for use in a piece of clothing, the tightness and density of the warp and weft can be varied to allow lesser or greater flexibility to the fabric; the ability of the material to fit to a complex shape can be tailored. By increasing the number of warps and therefore increasing the yarns per square inch, the risk of pinholes in a composite fabric can be reduced. Edward S. Van Dusen used this characteristic in his Lightweight Advantage Shell[20] (Figure 1); the tightly woven composite fabric provided the ideal material to create the lightweight watertight curved shape for the hull of the high-speed yacht. And also like a fashion textile, the individual yarns can be inter-changed to create the pattern desired. The patterns in engineered textiles depend on the properties desired; they can provide strength in a certain area or stiffness in a specific direction. J.P. Baudet and Luc Dubois's 3DL Sail[21] (Figure 2) uses the adaptability available in textiles to tailor the material to a high performance application; consisting of a woven textile of continuous carbon and aramid fibres laminated in Mylar resin, the pattern of the weave is designed to carry the specific load paths found within the sail. This precise tailoring of the material to the specific requirements ensures only material essential to the functioning of the object is used, thus reducing weight, vital in high speed yacht racing.

Figure 1. Lightweight Advantage Shell, Edward S. Van Dusen

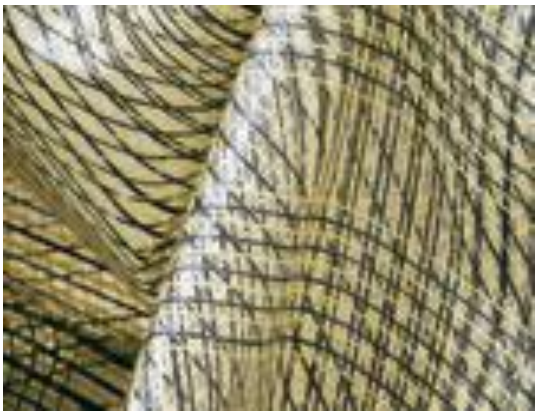

Figure 2. 3DL Sail, J.P. Baudet and Luc Dubois North Sails Nevada

[20] http://www.vandusenracingboats.com/ (15/05/2008)
[21] http://www.northsails.co.il/len/apage/26654.php (15/05/2008)

Brown[22] describes the qualities endowed in textiles from their creation process - flexibility, shaping, pattern design and tailoring - as being dependent on the interaction between the materials properties and the structural geometry and ordering of their assembly. If the process creates the qualities needed, what could happen if new materials were used in the traditional textile production methods?
Traditional weaving and knitting tools have been built to accommodate new 'yarns', from glass and carbon fibres to metal wire. The combination of the structural qualities created by weaving or knitting and the improved material properties of metals and glass has yielded dramatically different results in terms of strength and toughness, and has therefore extended the range of textiles into many more high performance applications. Catalytic converters show this progression into using textile processes and advanced materials to create high performance structures. The ceramic core of a catalytic converter is very sensitive to shock and impact and can be damaged by vibrations experienced within the automobile's engine environment. By incorporating a knitted metal wire shield[23] (Figure 3) around the outside of this delicate core, catalytic converters now provide better resistance to vibration due to the tiny springs created in the knitted metal wire structure, which cushion the ceramic core and prevent any damage from shocks.

Figure 3. Knitted metal wire shield for a catalytic converter

Experimentation with advanced materials in textiles has highlighted special properties above those of the additional strength and toughness provided by the improved material qualities. The stiffness of many of the new materials used in the traditional weaving and knitting processes have enabled the structures created to support themselves; thicker three-dimensional textiles can be produced.

> *"Whereas textiles are often seen as flexible forms of a specific length and breadth, the addition of a customizable thickness of up to 5cm (2in) and variable from area to area, enables us to think about textiles as blocks of material that have volume."*[24]

As Dent describes above, a textile is no longer just a flat cloth, needing structure to be added to it through a secondary process. Through advanced weaving processes and sophisticated material use, textiles can create forms themselves.

[22] Brown, Susan, 'Textiles: Fibre structure and function' in *Extreme Textiles*, ed. Matilda McQuaid, Thames and Hudson, Cooper-Hewitt National Design Museum, 2005

[23] http://www.knitmeshtechnologies.com/automotive/catalyticmeshwraps.html (15/05/2008)
[24] Dent, Andrew, 'Material Overviews' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997

This brings up an interesting question. Aesthetic and decorative qualities, according to McQuaid[25], are not requirements for technical textiles. The earlier examples in this section agreed with this; the composite used in the hull, the tailored weaving pattern in the sail and the knitted metal catalytic converter all use the properties produced by textiles for functional requirements alone. However, the advancing ability of textiles to create three-dimensional forms blurs this line between the functional aspect of the textile, and the growing aesthetic qualities created with it. Do technical textiles need to have a purely functional aesthetic in order to perform to the high levels required, or can new advancements into the materials and processes create a textile with both a desirable aesthetic and functional performance, creating an entirely new personality for the product?

3.3. Aesthetic Textiles

Considering the skill of craftsmanship needed to create the beautiful patterns and textures present in textiles, it can be said that textiles can belong in the field of crafts. A craft is a difficult thing to define. Some define it as an art form in itself, others a skill one acquires to design other objects. Dormer[26], however, defines a craft as *"intellectually isolated from both the pursuit of beauty (art) and purpose (design)"* and *"a process over which a person has detailed control, control that is the consequence of craft knowledge".* While the qualities in a craft object may lie somewhere in-between the aesthetic and the functional, the essence of a craft has always been in the physical nature of the objects produced. As Greenhalgh[27] says, *"craft stood exactly for the making of things".* Metcalf[28] expands on this definition by his understanding of the historical traditions behind many of the crafts around today:

> *"to some degree craft can be identified by the use of traditional craft materials, use of traditional craft techniques, and addressing a traditional craft context."*

This is not to say that craft objects cannot use modern materials or processes, but that in order for the object to retain the elements that define it as a craft, it must use at least one of these criteria identified; a craft object must have some sense of the traditional aspects of its historical evolution.
The accumulated knowledge of materials and evolution of craft processes over the many centuries is the invaluable aspect of the craft industry today. The textile craftsmen were concerned solely with developing a deep understanding of the materials they were dealing with and processes they used to craft them. It is this deep understanding of the materials they use and the processes involved which makes craftsmen the key to innovation in modern design. As Kate Russell, a professional craftswoman, says:

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[25] McQuaid, Matilda, 'Introduction' in *Extreme Textiles*, ed. Matilda McQuaid, Thames and Hudson, Cooper-Hewitt National Design Museum, 2005
[26] Dormer, Peter, '*The* salon de refuse?' in *The Culture of Craft*, ed. Peter Dormer, Manchester and New York: Manchester University Press, 1997
[27] Greenhalgh, Paul, 'The history of craft' in *The Culture of Craft*, ed. Peter Dormer, Manchester and New York: Manchester University Press, 1997
[28] Metcalf, Bruce , 'Craft and art, culture and biology' in *The Culture of Craft*, ed. Peter Dormer, Manchester and New York: Manchester University Press, 1997

> "*by examining and handling the physical stuff we can learn it's inner logic"*[29].

This focus on the materials and processes used in the crafting of textiles can create an aesthetic which is divorced from the function of the object. The aesthetic qualities of craft items are often valued over the functional aspects of the design. As Quinn remarks:

> *"No longer intended for practical use alone, materials are playing an important role in taking aesthetics forward."*[30]

The materials and processes used are now not only vital for creating the solid functioning structure of an object; they are becoming the key factors for determining the aesthetics and personality of a product as well.

The aesthetics of textiles are the quality which most consumers (and possibly designers) consider first. Although the advancements in high performance textiles highlighted earlier prove that textiles are capable of many demanding and wide-ranging applications, historical use of textiles in purely aesthetic applications has created a tradition for the 'look' created by a textile. Textiles are often considered as soft draping forms or delicate complex patterns. These stereotypes of textiles are deep rooted in the history of their designs, and as such provide a familiarity to the users. This traditionalism of a textile design does not make the aesthetic it provides any less beautiful.

The aesthetics of the textile, the weave pattern and texture, the variation in the yarn, the complexity of the structure of the cloth, are always present from its crafted creation. Using the flexibility of the cloth itself, this aesthetic can then be applied to many different objects, other than for fashion alone. A convergence of craft skills can enable textiles to express their aesthetic in surprising and innovative ways. Stephen Burks' 'Missoni glassware'[31] (Figure 4) uses scraps of leftover fabric to create sculptural glass vases. The incorporation of fabric in glass challenges the conventional perception of the use of materials; glass is not conventionally thought of as patterned, fabric not considered to be sculptural and solid. The qualities of the textile, its unique aesthetic and ability to drape around forms, were recognised by Burks and combined with the merits of another craft

Figure 4. Missoni Glassware, Stephen Burks

[29] Russell, Kate and Barnett, Pennina, 'Craft as Art' in *Women and Craft*, ed. Gillian Elinor, Su Richardson, Sue Scott, Angharad Thomas and Kate Walker, Virago Press Limited, London, 1987
[30] Quinn, Bradley, 'Introduction' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997
[31] http://www.apartmenttherapy.com/ny/inspiration/stephen-burks-patchwork-missoni-vases-031659 (15/05/2008)

discipline to create a new form. The adaptability of textiles allowed this cross-discipline collaboration. Textiles are a multi-faceted material, with many functional and aesthetic qualities, which through experimentation across disciplines proves textiles to be a *"material that seems to have infinite possibilities because of its ability to conform to a shape, be joined, folded or overlapped"*[32].

3.4. Textile Innovations

The potential for the cross-discipline experimentation with textile materials and processes is slowly beginning to be recognised by both the design and science worlds. The innovations in technical properties and aesthetic qualities are positioning textiles as an incredibly versatile material within the constantly evolving area of design:

> *"From the traditional to the intangible, from the technical to the tectonic, the exchanges taking place between materials and design are forging a uniquely multi-disciplinary arena"*[33]

Designers and architects are becoming more aware of the applicability of textiles in their work, and through their experiential combinations of advanced materials and traditional craft aesthetics, are creating innovative new personalities for their products. Braddock describes this incorporation of textiles in objects by designers as affecting the entirety of the product; both the technical capabilities and aesthetic appeal:

> *"the textile becomes part of overall visible design as well as the technical solution"*[34]

Figure 5. Knotted Carbon Fibre Chair, Marcel Wanders

This combination of advanced materials with a traditional textile process created a particularly interesting set of qualities in Marcel Wanders's Knotted Carbon Fibre Chair[35] (Figure 5). Here Wanders uses the traditional craft textile process of macramé (knotted yarns to create structure and patterns), but in place of the traditional twine, uses an advanced carbon fibre material. The resulting piece of furniture creates an aesthetic associated with the delicacy and flexibility of textiles, with the functional, and surprising, solidity provided by the use of the high performance carbon fibre.

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[32] Quinn, Bradley, 'Material Intelligence' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997

[33] Quinn, Bradley, 'Material Intelligence' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997

[34] Braddock, Sarah E. 'Architecture' in *Techno Textiles 2*, ed. Sarah E. Braddock and Marie O'Mahony, London: Thames and Hudson, 2007

[35] http://www.marcelwanders.nl/wanders/pages/seaters-knotchair_1_8_grouppage.shtml (15/09/2008)

The use of a traditional textile process with advanced materials to create what could be termed a 'modern day craft aesthetic' is also used by Thomas Heatherwick in his 'Boiler Suit' façade in Guy's Hospital, London[36] (Figure 6). Heatherwick's use of the ancient architectural textile technique of wattle and daub with modern stainless steel strips and mesh has transformed the once purely functional qualities of the process into aesthetic values which add an entirely new appearance to the façade of the building.

Figure 6. Boiler Suit façade,Guy's Hospital, London, Thomas Heatherwick

This recognition of the validity of old techniques and manufacturing processes in modern day architecture and design is not only valid for the aesthetic they bring, however, they can also add to the functional capabilities of the structure if modern materials can be applied in the process. Beesley and Hanna think this is a particularly valid concept in modern architecture, as advancements in lightness, efficiency and strength are always being investigated:

> *"the basic concepts of ancient wattle-and-daub and thatch techniques still apply to these lightweight building systems"*[37]

This experimentation with advanced materials in traditional processes to provide functional improvements to a structure is demonstrated perfectly in Peter Testa and Devyn Weiser's Carbon Tower[38] (Figure 7). Here Testa and Weiser have incorporated textiles into the core of their design, enabling them to design a completely composite high-story building with an innovative earthquake shock absorption system. Recognising the benefits of carbon fibres, which have a tensile strength five times greater than steel, and using 'knitted' interlocking weaving mechanisms to distribute the load throughout the flexible helical structure, Testa and Weiser created a revolution in thinking regarding the applicability of textiles in the highly demanding industry of large-scale architecture.

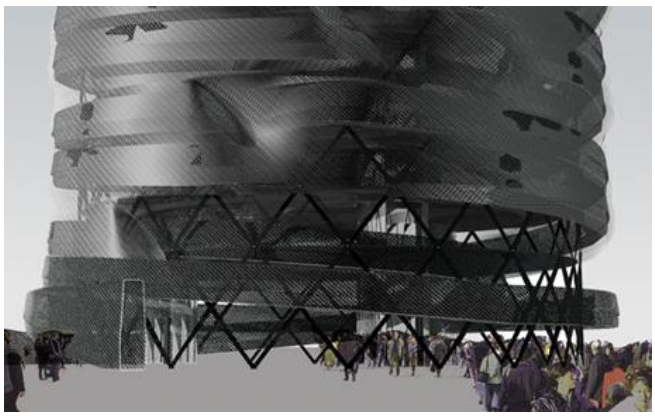

Figure 7. Carbon Tower, Peter Testa and Devyn Weiser

[36] http://www.london-se1.co.uk/news/view/2865 (15/09/2008)
[37] Beesley, Philip, and Hanna, Sean, 'Introduction' in *Extreme Textiles*, ed. Matilda McQuaid, Thames and Hudson, Cooper-Hewitt National Design Museum, 2005
[38] http://erinaardianto.com/carbontower.html (15/09/2008)

The experimentation of materials and processes does not have to be restricted to advanced materials and processes already associated with that application however; the functional and aesthetical qualities and capabilities of any materials and processes can be combined so long as they are known about and understood. Architect Mark West recognised the ability of textiles to carry tension and stretch and form to complex shapes, but wanted to be able to make these structures solid. Here he combined his architectural knowledge of the compression capabilities of concrete to his new found appreciation for textiles and developed Fabric Formwork[39] (Figure 8). This technology uses the adaptable corset technology of reinforced textile sheaths joined with eyelets and laces impregnated with wet concrete to create curved sculpted forms and complex geometrical solid structures.

Figure 8. Fabric 'curtain' made from Fabric Formwork, Mark West

In order to develop this innovative new method of moulding concrete forms, West combined two separate areas of his knowledge; the structural solidity of concrete and the creative flexibility of textiles. It is this combination of knowledge and recognition of the capabilities and applicability of textiles which can make innovations like this. Many of the innovations in modern textile applications mentioned above have had some element of crafts in them. According to Dalton, this innovative use of crafts in alternative design industries has been down to an increased interest in the craft movement, and a resulting increase in the knowledge of craft techniques and the benefits they can bring to both the aesthetic and functional qualities of a product.

> *"the positive result of this has been the stimulation of interest and awareness in crafts and the re-activation of craft skills and techniques"*[40]

[39] http://www.umanitoba.ca/cast_building/assets/downloads/PDFS/Fabric_Formwork/Brief_Description_of_Fabric_Formed_Concrete.pdf (17/09/2008)

[40] Dalton, Pen 'Housewives, Leisure crafts and Ideology: De-skilling in consumer craft' in *Women and Craft*, ed. Gillian Elinor, Su Richardson, Sue Scott, Angharad Thomas and Kate Walker, Virago Press Limited, London, 1987

It is not only the design industries which have benefited from the innovation that increased knowledge about craft processes and textile technologies, however. It was mentioned earlier that textiles have been traditionally used for clothing due to their ability to shape to the human form. Advances in material science and the recognition of the functional capabilities provided by the unique structure of textiles have lead to the development of textile implants; textiles are now clothing our internal organs too. Acorn Cardiovascular Inc., a medical device company in Minnesota, realised the potential for textiles in cardiac support devices for heart failure patients. The flexible knitted structure of the CorCap Cardiac Support Device[41] (Figure 9) enables the textile to conform to and support the heart's shape, whilst still allowing normal cardiac functions. Professor

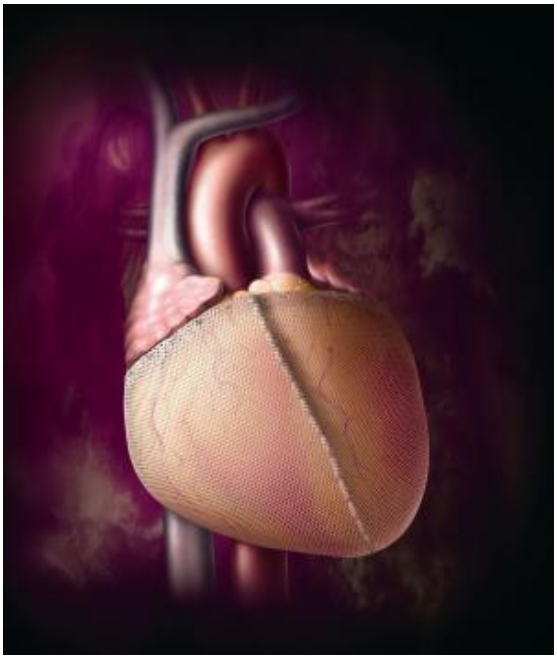

Figure 9. CorCap Cardiac Support Device, Acorn Cardiovascular Inc

Simon Frostick also recognised the benefits offered by the flexible textile structure and has applied it in a beautiful manner. Frostick's Bio implantable device for reconstructive shoulder surgery[42] (Figure 10) uses the ancient craft process of lacework with a modern day medical material to create a supple and compliant implanted brace for damaged shoulder muscles. The manufacturing process of machine embroidery on a base cloth also means that this innovation in implantable medical textiles can be tailored specifically to each patient's needs.

Figure 10. Machine embroidered Bio implantable device for reconstructive shoulder surgery, Professor Simon Frostick

[41] http://www.acorncv.com/healthcare_providers/corcap.cfm
[42] McQuaid, Matilda *Extreme Textiles*, ed. Matilda McQuaid, Thames and Hudson, Cooper-Hewitt National Design Museum, 2005

The innovations in functionality and aesthetic quality provided by the experimental use of textiles described in this chapter have only come about through the application of knowledge and open-minded creativity in design. The advances in material science provide more and more capable materials to use in the objects designers create, but the preservation of knowledge of traditional craft and textile manufacturing processes and the recognition of their applicability in the modern day have proved equally valuable. As Quinn puts it:

> *"Today, textile design, metalwork, ceramics and glass are advancing dramatically as material science identifies new techniques and uncovers cross-disciplinary potentials, yet the touch of the human hand still remains as important as ever. As material science continues to broker even more interdisciplinary exchanges, the boundaries between science, technology, craft and design blurs even more."*

The products described in this section are prime examples of the importance of these interdisciplinary exchanges in creating innovations in both function and appearance. It is vitally important for designers to understand aspects of other disciplines and recognise the potential for applying this knowledge in their own fields. The question is how can designers gain this knowledge so useful to creating innovative products and open their minds to textiles?

4.

Man

4.1. Enlightening Innovations

The bulk of this thesis poses the argument for the innovative use of materials in surprising applications. It discusses why it is so important for designers to recognise both the functional capabilities and aesthetic qualities of textiles and their manufacturing process, and the value of interdisciplinary design in creating innovative new products. The examples given above seem to make creating cross-discipline connections easy, but very few products today apply this philosophy.

Setting aside wide jumps in interdisciplinary design thinking, there is still a mediocrity of experimentation within individual design disciplines, especially when it comes to mass manufacture products or large commercial ventures. Traditional materials are used in many products, and conventional manufacturing processes are regularly employed. Often on a cost basis, the 'standard' materials and manufacturing processes are preferred over more unconventional experiments. Until the unconventional overcomes the cost of entry into the traditional design world and becomes the conventional, its value will only be limitedly appreciated. It is designers who must challenge convention and extol the virtues of a new found material application or process.

However, the wide range of materials available and their surprising capabilities and applications are often overlooked by designers. It is the knowledge of different material's capabilities which is necessary in creating new applications:

"creating an awareness of materials is one key to innovation"[43]

It is this knowledge of a material's existence and an experimentation with its capabilities and manufacturing processes which is essential in the creation of innovative new products. This is a problem which is facing textiles. Having been used for so long in traditional clothing and soft furnishing designs, designers may consider textiles to be only capable of soft and drapable applications; of providing an aesthetical cover to a functional structure. The previous section demonstrated that this is definitely not the case, however the problem is to get other designers to understand this.

Part of the problem with the uptake of textiles as a medium in the design of products comes down to the designer's fear of working with the material. Textile design is not often taught specifically in design schools, and so when it comes to applying it in a product, the skills needed to manipulate the raw textile materials effectively might be missing. The traditional craftsman's skills in the textile manufacture process are especially required when the textiles are being experimented with in order to create innovative aesthetics and functions. These skills are learnt over many years, and this time needed to master a manufacturing process can be off-putting to designers who are thinking about applying textiles in their products. The end result of this complexity in learning textile crafting skills is often the disregard of textiles as a mainstream material to be used in products, either due to fear of the unknown or simply unawareness of their existence or applicability.

[43] Quinn, Bradley and Caniato, Michelle 'Material Maestros' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997

For those designers who have some knowledge of textiles and have the craft skills to manipulate them, the application of them to their products is an exciting and apparent design solution. Often the designers will have been taught these skills early in childhood, and developed the use of textiles and craft skills in their designs. However, there is frequently a stereotypical distribution of these skills and knowledge of textiles and crafts towards women, and Dalton believes this may be down to stereotypical teaching of skills as children:

> *"in her childhood the little girl has probably been given a sewing kit whilst her brother has a tool set"*[44]
>
> *"In schooling the conditioning process continues to train the young women into habits and skills that make the association between women and textiles a natural one"*[44]

Russell believes this separation of knowledge goes even further than the prevention of male designers experimenting with textiles, but that it even creates an attitude of disregard for the use of textiles in products as feminine and therefore insignificant:

> *"Anything to do with fabric is derisively called 'knitting', with the inference of knitting circles, women's gossiping circles – in other words, triviality, domesticity, non-seriousness."*[45]

This disregard for textiles by designers due to lack of knowledge or lack of respect may be generalisations, but they do bring up an interesting question. If it is the case that the specific knowledge of textiles and the respect for the applicability of it as a valuable material is being narrowed down to a selection of mainly female professional artists and craftsmen, how can designers hope to experiment with new materials and processes and create innovations in their products that would not have existed without textiles?

The answer is interdisciplinary design. In this day, with the vast range of materials and processes available to designers, it is unrealistic to think that designers will have knowledge of all the possibilities which they can apply to their products. Designers, craftsmen and engineers can become experts in their narrow fields, and so may become ignorant as to the other possibilities outside of their own discipline. It may take outside eyes looking into a new area of knowledge to create an innovative use or process for a material. As discussed earlier, materials form a system of capabilities, and Beylerian adds to this by discussing how materials can often be applied outside of their traditional function:

> *"it is not to say that these specific materials cannot venture outside their specific role. Indeed, the cross-utilization of knowledge and materials will be one of the most important features of future developments in materials art and innovation."*

[44] Dalton, Pen, 'Housewives, Leisure crafts and Ideology: De-skilling in consumer craft' in *Women and Craft*, ed. Gillian Elinor, Su Richardson, Sue Scott, Angharad Thomas and Kate Walker, Virago Press Limited, London, 1987

[45] Russell, Kate and Barnett, Pennina, 'Craft as Art' in *Women and Craft*, ed. Gillian Elinor, Su Richardson, Sue Scott, Angharad Thomas and Kate Walker, Virago Press Limited, London, 1987

O'Mahony examines the responsibility of designers to investigate the offerings of different industries and apply these new technologies to their products[46]:

> *"sophisticated materials and technologies force designers to examine working practices"*

This overlapping of technologies, industries and disciplines and the increase in value that the joint advancement of knowledge adds to a product is gradually being recognised throughout the scientific and design industries:

> *'blurring of boundaries between creative disciplines is leading the way forward into new aesthetic territories, the concept of cross-fertilizing materials and technology is becoming the rule rather than the exception in the quest for innovative solutions'*[47]

Multidisciplinary design inspires innovative solutions to be found by crossing over boundaries which were previously considered the norm. By taking a simple manufacturing process and applying a new material, or taking a form and applying a new material or process, designers can force a product to do exactly what is required, and not what is traditionally expected. As Wilson comments:

> "*real innovations and leaps in technology and design are not the result of incremental improvements. Rather they are the result of disruptive thinking by innovators, born of radical experience or challenges"*[48]

The solution then for innovations in textile use in designs is for designers to abandon the stigma they may assign to textiles as functionally incapable or aesthetically trivial and give textiles the potential they deserve. And if the knowledge for their application or manufacture is lacking, designers should seek out experts who do have the experience and create cross-disciplinary design philosophies. This way science can influence design, and design can influence science, generating a perpetual advancement of the functionality and personality of products that are created.

4.2. Emotional Innovations

Experimentation with materials and processes may produce innovations in the eyes of the design world; however, the products resulting from this creativity can only be successful if they are accepted by the consumers who interact with them.

Consumers build up important relationships with the products they use. The usability and visceral appeal of products makes a profound effect on the user's overall impression of a product. As discussed earlier, their previous experience of a similar product or material can set a precedent for their expectations of the performance of the new product. The users can become accustomed to the conventionality of material use in products. A confidence in the functionality and aesthetic appearance

[46] O'Mahony, Marie, 'Design' in *Techno Textiles 2*, ed. Sarah E. Braddock and Marie O'Mahony, London: Thames and Hudson, 2007
[47] Antonelli, Paola, 'Foreword' in *Supernatural: The Work of Ross Lovegrove*, London: Phaidon Press, 2004
[48] Wilson, Patricia, 'Textiles from novel means of innovation' in *Extreme Textiles*, ed. Matilda McQuaid, Thames and Hudson, Cooper-Hewitt National Design Museum, 2005

given by a certain material to a product is developed which can be hard for designers to challenge.

Considering the usability of a new product, Dent[49] describes how consumers are often unwilling to tolerate cumbersome technology or inappropriate materials unless the product proves to be very useful in another respect, for example heavy body armour for soldiers, or pacemakers for cardiac patients. However, when a product is merely a commodity, the user becomes rightly fastidious, and *"general acceptance .... will probably only come when technology forms an integral part of the fabric and cannot be seen or felt"*.
The usability of a product is often not the determining factor in the user's overall impression of a product, however. Ashby describes how it is the personality of a product which can create a competitive appeal to the consumer:

> *"When many technically equivalent products compete, market share is won (or lost) through its visual and tactile appeal, the associations it carries, the way it is perceived and the emotions it generates."*[50]

Norman describes the design of products in this respect as 'visceral level design' where "*physical features – look, feel, and sound – dominate"*[51]. These aspects of a product will create the first impression to a consumer, and if they are unexpected movements away from the conventional then the user may misunderstand the object's personality. Norman describes this recognition of an object's meaning and function as a *"conceptual model"*[52] of the product. If the visceral aspects of the product convey one emotional message but the functional elements produce another, then the user's expectations are confounded, and their trust in the materials violated.

This is the problem facing products created using textiles in innovative new applications. The user places a trust in the material used in the object based on their previous experiences; they anticipate the product to conform to a certain set of expectations based on their knowledge of the materials capabilities:

> *"trust implies several qualities: reliance, confidence, and integrity. It means that one can count on a trusted system to perform precisely according to expectation."*[53]

Take Marcel Wanders 'Knotted Chair' discussed earlier. The loosely woven yarn structure appears extremely delicate and unable to bear weight. The carbon fibres which are used in place of the traditional yarn are incredible strong, however. The aesthetics of the chair are conveying a message of weakness to the viewer, while actually being capable of the exact opposite. The viewer constructs one conceptual model of the chair in their mind while the designer is trying to demonstrate another.

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[49] Dent, Andrew, 'Material Overviews' in *Ultra Materials: How Materials Innovation is Changing the World*, ed. Bradley Quinn, United Kingdom: Thames and Hudson, 1997
[50] Ashby, Mike, Johnson, Kara, 'Design and Designing' in *Materials and Design: The Art and Science of Material Selection in Product Design,* London: Butterworth-Heineman, 2002
[51] Norman, Donald A. 'Three Levels of Design: Visceral, Behavioural and Reflective' in *Emotional Design*, New York: Basic Books, 1988
[52] Norman, Donald A. 'People, Places and Things' in *Emotional Design*, New York: Basic Books, 1988
[53] Norman, Donald A. 'People, Places and Things' in *Emotional Design*, New York: Basic Books, 1988

Unless the viewer is educated in the functional capabilities of the chair, they will no doubt avoid sitting in it for fear of it collapsing.

This example demonstrates that the very innovations which designers are striving towards can be mistrusted by their consumers. The advanced functions or creative processes are unnoticed because users do not correctly understand the personality of the product. Norman puts this down to differences in knowledge and preferences of the design and consumer societies:

> *"there is a fundamental conflict between the preferences of the popular audience and the desires of the intellectual and artistic community"*[54]

Designs that are more readily accepted by consumers use textiles and their benefits to meet the consumer's need more efficiently and in a more conventional manner. Textile innovations which are used in a subtle way can slowly introduce the benefits of textiles and their processes to the unaware public. For example, the waterproof and breathable membrane which is the advanced functional component of Gore-Tex fabric[55] is sandwiched between conventional inner and outer jacket fabric layers; the technical side of the textile innovation is hidden from the consumers view under the stereotypical clothing application. Conversely, Eleksen[56] uses the technical benefits of textiles to create a flexible wireless fabric keyboard, but plays down the aesthetic side of the material; the advanced technology of the ElekTex fabric is not trivialised in the users mind by any associations with the traditional textile appearance. The traditional associations consumers relate to textiles are used to Super Sack's[57] benefit; the conventional use and benefits of textiles in shopping bags were expanded to the tonne scale by the use of advanced materials to create a space saving alternative for solid metal shipping containers.

These examples show that by balancing the unconventional innovations created by experimental designers with the emotional familiarity of conventional consumer applications, a truly innovative and applicable textile product can be produced.

[54] Norman, Donald A. 'Design by Committee vs. Design by an Individual' in *Emotional Design*, New York: Basic Books, 1988
[55] http://www.gore-tex.co.uk/remote/Satellite?c=fabrics_cont_land_c&childpagename=goretex_en_GB%2Ffabrics_cont_land_c%2FFabricTechnologiesChapterOneLanding&cid=1179537201286&p=1179537201282&pagename=SessionWrapper (28/09/08)
[56] http://www.eleksen.com/?page=products08/elektexproducts/index.asp (28/09/08)
[57] http://www.bagcorp.com/container_catalog_basic_tubular.cfm (28/09/08)

5.

Opinion

5.1. Innovations in Textile Applications

The materiality of an object provides the product's personality; the functions which are utilised by the user, and the aesthetics which are appreciated by the viewer. Textiles, both in the materials they use and the processes they apply, can provide a new material with many functional capabilities and unique aesthetics. They are fighting a battle, however, against both the designer's lack of knowledge and skills, and the consumer's conventional view of their capabilities and applications. Experimentation by designers can create excitingly innovative applications of textiles in unconventional areas; applying new materials to traditional textile processes to enhance the functionality of the structure or fashion a new aesthetic appearance. These experimental new personalities often rebel against the conventional stereotypes of textiles applications, creating paradoxical appearances and capabilities which can confuse the trusting consumer. Balance is key; innovations in textiles applications are needed but in a manner that is not jarring to the consumer. The advances in function and form must also provide a sympathetic feeling for the consumer interactions.

One can say that the most innovative design is revolutionary. That experimental conceptual design which pushes scientific technology and design thinking is the only way in which textiles can be implemented creatively in unconventional applications. These types of products can create markets for consumers. Open-minded consumers are often surprised and delighted by the advanced technology and unconventional designs and therefore willing to use these new products. However, a more familiar technological application and emotional design is needed to develop the trust most consumers require in their interactions with products; a slower evolution of experimental design and unconventional applications is required.

A balance is needed between the desire for designers to creative innovative and experimental products which push materials to their boundaries, and the needs of consumers to use objects which are emotionally comprehensible. Materials and processes should still be experimented with, but the jarring new personalities of products should not be forced upon trusting consumers. This uninhibited experimentation with materials and processes and enhanced understanding of the material capabilities is vital in discovering new applications for textiles, but an appreciation of the emotional value of the product should be included in the design development, in order to increase the appeal of the product to the general consumer.

The examples discussed throughout show how the benefits of textiles have been used to create innovative products which consumers can still relate to. Textiles can offer their traditional aesthetic and trusting conventional application while providing innovations through the incorporation of advanced materials. They can forsake their aesthetic and become a purely functional material for use in highly technical applications. Or they can combine their aesthetic and functional capabilities and celebrate the textile process to create products with innovative textile applications and unique personalities.
These benefits which textiles offer are nothing without the creativity of designers, however. With the openness in attitude towards the potential of textiles, the

willingness to acquire the knowledge and skills needed to experiment with them, and the enthusiasm to explore other design disciplines, designers can reap the innovative benefits textiles can present. But the emotional value of the materials and the effect on the product's personality must also be considered. The innovative creations aspired to by designers will only be accepted by consumers at large if the trust they once associated with the materials function or aesthetic is not lost.

So how can the benefits of traditional textiles be applied to new products to create innovative aesthetics and functional designs? It is the experimental advancement of the material's capabilities and their processes, the increase of the designer's knowledge and skills and the slow acceptance of new emotional designs by consumers that together can weave a future for the innovation of textiles.

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