

# The Materiality of Wearable Computers – Craft and Authentic User Experience

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## Abstract

This paper will present two projects undertaken as part of the author's ongoing doctoral research into **Wearable Computers**, and the processes for designing personal digital artefacts that exhibit *materiality*. Materiality is discussed in its associations with the applied arts, and as a means by which tools may cease disappearing in the obsessively rational quest for what Heidegger called *readiness-to-hand*, and instead become more meaningful for users as objects in interaction. The overall aims of the research are to investigate evidence for the growing desire for authentic experience in everyday life, and to evaluate craft practice for its possible contribution to new design and build processes that can deliver this authenticity.

The bulk of the paper is concerned with the comfortBlanket project. Through the design of a 'smart' sensing cot blanket, bumper and monitor using the traditional domestic craft technique of patchworking, this project seeks to support the larger aims of the research by providing a context within which to test and reflect upon user evaluation methods. It seeks specifically to show that materiality, important in the finished product, also plays a crucial role in the user centred design process. Thus the evaluation sessions of the comfortBlanket concept designs seek to evaluate the design itself for its success as a familiar product as a result of its craft attributes, as well as the concept representations (2D presentation boards, physical prototypes etc) for the

kinds of understanding of the product the participant gains through each. The lessons learned from both of these aspects can then be applied to the design of the next stage of the research, the Expressions of Smart Materials project, and this is introduced in a short section at the end of the paper.

This work addresses the role of crafts in the development of personal technological products with the aim of creating interesting and viable sustainable design processes, by engineering a closer relationship between user and product. It does not cover the experiences of the maker, but rather concentrates on the experience of the user as a result of the making process.

## **Introduction**

The research this paper describes spans two main fields of activity – the arts, and human-computer interaction. It is differentiated from much of the writing disseminated through arts channels in that it does not concern the use of computers, new media or programming in the production of art works. Simultaneously, it is unusual in the HCI community for its basis in arts practice. Much has been said about the nature of craftsmanship as computing technology becomes available to the practitioner, but little has been said regarding the role of the craftsman’s sensibility in the development of computational products, and this is where the author hopes to contribute. The contradictory element of imperfection executed by the master craftsman is becoming increasingly important to consumers in search of a different pace of experience (Koren 1994; Lewis & Bridger 2000; Boyle 2003; Thompson 2004), and the research project thus concerns the design of digital products using craft

processes, rather than the computer aided design of everyday objects. It finds evidence for the validity of such an approach in the philosophies of Heidegger and Baudrillard (Inwood 1997; Baudrillard 1968), in the recent media and marketing literature (Datamonitor 2002; Boyle 2003), in advertising and product design (van Hinte 1997; Jordan 2000; Thompson 2004), and even in current embedded technologies research (Turner 2003; Turner 2003a; Underkoffler & Ishii 1999; Seymour 2003). The two projects making up the author's doctoral work are presented at their different stages, with a discussion of the methodological problems posed by this inter-disciplinary approach. As a starting point it would seem sensible to attempt definitions of the terms involved.

### **Materiality, Meaning and Authenticity**

Materiality has two main definitions. First, the quality of being physical, of existing of matter, and second, being a relevance requiring careful consideration (hyperdictionary). In different contexts it means the physical instantiation of a concept, appreciation and understanding through sensory interaction, real experience, embodied knowledge, and physicalised human experience. It is important in defining the tangible in a world of intangibles – products are frequently becoming services, with outcomes but no physicality of their own, and materiality is becoming something of a comforting concept for those feeling alienated by concepts of disembodied knowledge and narratives of cyberspace. The second definition is interesting in philosophical terms; phenomenologically speaking, functional products have long been designed to 'disappear' rather than to require careful consideration (Inwood 1997; Norman 1999; Verbeek 1997), and indeed Paul Verbeek has argued instead for an alternative non-Platonic design process, which focuses on objects 'not in terms of

origins, but of the ways in which things give shape to their environment' (Verbeek 1997). Thus materiality can be employed to signify an approach driven neither by functionality, as in modernism, nor by semantics, as in post-modernism. Instead, it can be seen as indicative of a return to 'the real' (Foster 1996), and as such is linked inextricably to the current movement of consumers towards authentic experiences and products (Lewis & Bridger 2000; Boyle 2003). The aim of the overall research is to build 'meaningful' wearable computational products, where 'meaning' is held to denote the non-disappearance of things, to stand for their contemplation and re-visitation by the user. It is thus the second definition of materiality that is of interest in creating this 'meaning' through required consideration, and meaning in turn is understood to be an essential element of authentic experience, closely related to characteristics such as rootedness, authorship and narrative (Kälviäinen 2000).

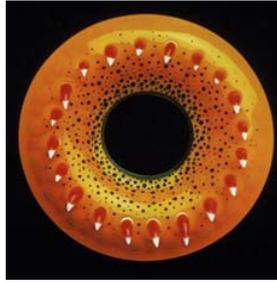
Recent research in the domain of wearable computing presents the everyday as the 'final frontier' remaining for this paradigm (DeVaul, Schwartz & Pentland 2001; Watkins & Dunne 2003). Verbeek's materially led design process may be a way of designing for the authenticity the everyday market increasingly desires. More importantly, if new technology products such as this are not to be discarded as soon as another function becomes available on an updated version, they need to encourage the consideration, even contemplation that creates meaning for the user. Thus sustainability through increased owner attachment to products may also be achieved. In seeking to apply this approach, the next section considers craft as a means of delivering authenticity.

### **Authenticity through Craft**

Mirja Kälviäinen, of the Kuopio Academy of Design in Finland, has explicated the elements of authenticity as including uniqueness, originality, difficulty of reproduction, the creation of else-wheres and –whens, perceived investment of time, collectibility or fetishistic properties, a rarefication through complexity of acquisition in a luxury market, or due to specialised knowledge required for consumption, identifiable authorship, a connection with the natural world through materials or traditional processes, inherent narrative, and intellectual associations (Kälviäinen 2000). Lewis & Bridger talk about ‘quality that fascinates’ rather than simply ‘quality that is expected’, about a spiritual element in consumption, and about more subtle demonstrations of wealth; their ‘new consumer’ wants to be involved and informed in order to make the most authentic choices (Lewis & Bridger 2000). Important elements include location of the product in a specific time and place, originality (uniqueness), and credibility through expertise, while a sense of reality, unmediated experience and trust are inherent to authenticity, and human contact and the materiality of products and services render them tangible and real for the consumer (Lewis & Bridger 2000; Boyle 2003). Narrative has also been shown as important in the attribution of value to otherwise random, mass-produced, and even aesthetically ugly objects (Csikszentmihalyi & Rochberg-Halton 1981).

Crafts practitioners are in a unique position today in being able to deliver the authentic experience demanded by today’s consumer (Kälviäinen 2000; Greenhalgh 2002; Press & Cusworth 1997). At it’s best craft is honest, it has integrity (Dormer 1997), there is a certain quality of ‘rightness’ felt in the object (Goring 2003; Nairne 2003) and the maker is held to be an expert by virtue of his experience and his resulting objective understanding of what is right and what is wrong (Dormer 1997). Further expertise surrounds the craft object in the gallery environment, complicating

the acquisition process and acting as an exclusive arena for involvement for the consumer. The culture of private views and the commissioning of unique work greatly personalise the process of consumption, the product is grounded firmly in time and place, authorship is unquestionably identified, and narrative is automatically embodied from the outset. The craftsman's presence allows the customer to feel connected to the process, to be part of a community, and even to feel that the heroic nature of the maker may be theirs by association. Time has unquestionably been invested in a crafted object, and increased knowledge on the part of the buyer will increase his or her awareness of the complexity and difficulty of processes. In disciplines such as silversmithing, this 'gift of time' was until the last century understood through the high finish of functional pieces. More recently silver has become an expressive material in its own right and has become part of a movement of contemporary craftspeople intent on exposing the making process in the object (see for example the work of Simone ten Hompel). The uniqueness of the artist's language can emerge through extending and testing the range of a material's expressive properties (Paxon 2001; Paxon 2003; Lichterman 2003), and this is also a kind of truthfulness, while exhibiting the quality of fascination mentioned by Lewis and Bridger. The possibility of transformation is a powerful metaphor for the new consumer, seeking to bridge the gap between their real and ideal selves (Kälviäinen 2000; Lewis & Bridger 2000), and craft can be seen to display this in its manipulation of materials and creation of value where previously there was none. For an example of this transformation, consider the work of contemporary jeweller Adam Paxon.



Adam Paxon, acrylic brooch

Using acrylic, Paxon invests it with value through thermoforming laminated layers, applying time consuming and skilful techniques to the new material. By deliberately using industrial coloured acrylic sheet, he is able to show how far from its original associations and expression a material can be brought (Paxon 2001; Paxon 2003). If material informs the process, then it is just such *intelligent making* that stops it from becoming formulaic (Press & Cusworth 1997), and as the elements of computation become design materials in their own right, it is crafts practice that will allow alternative values and aesthetics to emerge (Press 1996; Orth 2001).

The comfortBlanket project was designed to provide a context for investigation into methods for a user centred design process for wearable computers exhibiting materiality and encouraging an authentic user experience. It focuses on an aspect of phenomenological experience, familiarity, as an element of narrative, and uses patchworking as the central craft process, exhibiting Kälviäinen's 'gift of time'.

### **The comfortBlanket**

The comfortBlanket used recycled favourite children's clothes and patchworking to combine familiar materials and processes with unfamiliar technological components, which can cause legitimate concern for health or safety. The underlying concept of familiarity has been informed by Heidegger's philosophy of phenomenology, in

which familiarity plays an important part, and by similar approaches taken in other related design projects (Turner 2003; Inwood 1997; Hecht 2003; Colin 2001; Hallnäs et al 2001). The element of familiarity is not intended here to encourage phenomenological disappearance of the object, but rather to promote initial acceptance of it, and to allow the materiality afforded by the many small images in the patchworking technique to then take over. The design brief, taken from the D&AD Nesta Product Design and Innovation Awards call for entries, was to support patterns of waking and falling asleep. Three design boards presented the product as a set of specifications, as part of a user scenario, and as a background design concept.



Design Board 1: Product Specification

The blanket was conceived of as being part product, part service, involving the consumer in the manufacturing process through their role as supplier of favourite used

clothing, which the manufacturer would then use to make up a patchwork blanket unique to the customer, with the sensing technology fabric sandwiched between two outer layers. The user was defined as the parents and carers of young children whose sleep is frequently disturbed; sleep deprivation can cause stress and depression, and so while it is the child who is comforted in the first instance, the primary user is seen to be the adult.



6pm: The family arrive home after a long day. Kids exhausted and in need of food.



6:30pm Tea is served.



7:00pm All in the living room, watching the end of children's TV.



7:30pm Quiet time. Ben and Lucie make up stories about the characters on the **comfortBlanket**.



7:45pm Lucie put in her cot. The **bumper** plays a lullaby which we recorded, and this helps her get off to sleep calmly.



8:00pm I take the **monitor** unit into the kitchen with the **intercomm** on one way while I clear up.



1:00am Lucie stirring in her sleep. I give her a little "cuddle" by stroking the pads on the monitor. To feel in touch with her, I keep checking the pulsing heartbeat pad too.



3:30am A bad night by our new standards; Lucie can't be comforted and I go through to pick her up. We take the **blanket** through to the living room for a cuddle, and she falls asleep quite quickly.



7:00am Bliss! We get a lie in! The kids stay in their room till 7am singing along with songs on the **bumper**, and making up stories before they come through to see us.



# comfortBLANKET

## Design Board 2: Product in Context

The sensors in the blanket pick up movement and temperature information, sending this wirelessly to a processor in the monitor, which can be kept by the parents' bed or placed in other rooms around the house as needed. When a child is about to waken, changes in temperature and agitation occur, and these are recognised by the program, triggering soothing reactions from the blanket and bumper in the form of a nightlight display or recorded sound, such as a lullaby or a heartbeat. Where the child would

normally have woken, it is now lulled back to a restful state, allowing sleep to continue. The monitor also allows the parent awareness of the child and what the blanket is doing through ambient light levels on the monitor. The monitor can be set as a normal baby monitor, to allow one or two way intercom communication.

### Familiarity in cutting edge technology

A unique service from the National Childcare Trust. Send your favourite used children's clothes to us and we will create a beautiful patchworked blanket utilising sophisticated sensing technology to help you and your child sleep soundly at night.



**Safe** - The low power working parts are embedded within a sandwiched layer of fabric, and are safe for you and your child.

**Practical** - Because the technology is part of the fabric structure itself, the blanket can be washed as normal.

**Aware** - We think it is important in today's world to encourage sustainable product consumption. This service plays a part in keeping craft practices alive and uses 90% recycled materials. It continues the age old tradition of patchworking.

#### How the blanket and bumper help soothe your child

**Sound** - White noise, your voice - simulates sounds heard in the womb, while the mother's voice indicates safety. Use the preset recordings or make your own to be played through the hidden speakers in the bumper.

**Touch** - skin on skin contact has been shown to be important for newborns, and later recalls feeding contact with the mother. Stroke the fingerpads on the monitor to reassure your baby in her cot.

**Sight** - Soft night lights are set into the bumper, and glow on when the baby moves. No need to be afraid of the dark.

**Familiar** - Technology need not be intimidating for either you or your child. This unique service from NCT Crafts personalises this interactive product so that it becomes a part of your daily life immediately, and forms a part of your



#### How your mind is set at rest by the mobile monitor

**Temperature** - An ambient display lets you know if your child's temperature is at the right level for sleep.

**Heart rate** - Your baby's hear beat is translated into regular pulses felt through the palm area on the monitor.

**Sound** - You can choose to hear your child through the intercomm.

**Rest** - Sleep deprivation has been shown to play a large part in parental stress and depression. The comfortBlanket helps break the habit of waking in the night.



Keep a look out for future craft and technology products from NCT.

# comfortBLANKET

### Design Board 3: Design Concept

The first version of the comfortBlanket was designed around Sensatex technology, a proprietary technology weaving sensors and computational functionality into fabric structures (Sensatex.com). According to the promotional literature, this allows the technology to be subsumed into the look and feel of the fabric, which remains flexible. Because Sensatex remains unavailable for testing, however, alternative specifications have been considered, and a more recent version has been designed using Capacitance-to-Analogue Converters (CACs) embedded in the bumper,

measuring movement through the detection of PVDF foil strips embedded in the blanket (Quantum Research Group).

It was never intended to fully implement the comfortBlanket. Rather, it serves as a context for research into the novel technologies being developed relevant to wearable computing, and for critical consideration of evaluation methods appropriate for concept designs that aim to be simultaneously expressive and functional. While there are methodologies for the evaluation of each of these aspects independently, they would seem to be mutually exclusive (Jordan 2000; Preece 1994). Add to this, the problem of evaluating a product using non-functioning prototypes, and the visual designer of expressive computational systems faces what appear to be insurmountable problems. There is an absence of development environments for the non-(technical) expert, as are available for the prototyping of Graphical User Interfaces, and other prototyping and evaluation strategies need to be explored (Galbraith 2001). This will allow designers from a wider range of disciplines to become involved while also supporting the technical designer in what can be an expensive and time consuming process. If materiality is important in the evaluation of design concepts with users, then the more physical and functional iterative prototypes can be, the better the feedback, yet even very experienced teams put the development of a wearable system with novel exterior design at a minimum of a year (Dorsey & Siewiorek 2003). In recognising this increasingly common problem, the comfortBlanket is being used as a physical instantiation of a concept, supporting user understanding in evaluating unfamiliar technological products, and allowing the researcher to reflect on the methods used in understanding user perceptions.

## **Evaluation Methods**

The methods described here were designed to allow for evaluation of the design itself in terms of its familiarity and materiality, and to allow for reflection on the methods used. The participants are self-selecting carers of children, including childminders, nursery staff and parents, from the Edinburgh area. Three representations of the concept design were planned for evaluation:

- 2D design boards, aiming to support cognitive understanding
- an animated Flash scenario, aiming to contextualise the product in use
- a physical prototype, aiming to support fuller sensorial understanding

A 'cultural probe' type activity was also planned to elicit background attitudinal information, based on a combination of sociological approaches (Csikszentmihalyi & Rochberg-Halton 1981), with that used by the Presence Project to understand users' lifeworlds (Gaver, Dunne & Pacenti 1999).

### *Concept Representations*

A word concept association method adapted from IDEO's methods cards (IDEO 2003) is applied to a series of concept design representations to compare the perceptions of the participants to each. The descriptive word cards have been prepared heuristically, although extra blank cards and pens are made available to allow unexpected associations to arise. These are selected by the participants and placed next to the design representation in question; while doing this the user is asked to speak aloud and a rich verbal protocol is collected. The descriptive words are recorded for each representation in turn, and discussion after all the design

representations have been considered is encouraged and recorded to allow the participants to reflect on their perceptions.

The expectation in designing the methods was that with an increased progression of materiality in the mode of representation, involving more of the senses, the discussion would become rounder, with concepts and affective reactions both effectively articulated by the participants. It was expected that it would become easier for the users to critically engage with both technological and aesthetic issues as materiality of the presentation increases, yet stopping short of uniting functionality with aesthetics. The results were expected to show that the more senses are engaged in evaluating a concept, the more complete the understanding of the participant, and the more useful the feedback.

### *Cultural Probe*

This exercise collects information on the meanings associated with objects connected with infants, and provides attitudinal information on the user regarding themselves, technology, and close relationships with other people. It seeks to discover intrinsic and extrinsic meanings seen in personal belongings, and to link these with formal design elements, and to link any craft attributes found in the narratives of these objects to affective meaning. Participants are asked to make a visual record of an object they feel particularly has meaning in connection with their child. Although the most obvious type of object might be expected to be a representation of the child himself, such as a photograph in a wallet, this is invalid for the research, because we are more interested in how relationships may be mediated through inanimate objects rather than pictorially re-presented. The visual record is made by the participant using

a disposable camera, guided by a written series of prompts, and showing the object itself, its design characteristics, its static context, and context in use. The images then form the basis of a semi-structured discussion led by the researcher, also recorded for later analysis.

### *Reflections on the Pilot Session*

A pilot session was held with a group of enthusiastic childminders, and yielded some important insights into managing the evaluation sessions. The chaotic nature of the session, with participants arriving at different times, and with the presence of a number of small children, precluded the use of any of the methods planned. Recording was a problem due to the level of background noise and the extremely disjointed nature of conversation. The generally disorganised viewing of the design representations led to participants feeling all were essential and interrelated, and reactions were continually mediated by discussion with the researcher. Thus, if the methods are to be tested at all, meetings need to be arranged without children present and set to start at a given time. While pairs or small groups can provide particularly dynamic and rich verbal protocols, recording issues need to be resolved, or individuals can equally effectively be used. Conducting the session within users' own homes appears to put participants at ease, but workshops could also be arranged in locations such as at the university, in community centres, or schools. More radically, there may well be a case for regimenting the process less rather than more, and for the researcher to immerse themselves in the users' environment for the duration of the evaluation. This approach may be useful in the way of 'quick and dirty' ethnographically informed methods, and could allow a more natural range of

expression to emerge (Carroll 1997), while obviously posing problems for data capture.

## Results



A participant's completed word association activity with 2D design boards and physical prototype

The concept design boards have been presented to the individual participants first with instructions to ask questions about the design as needed, and to select description cards from the provided pile while thinking aloud. Most participants sought extra clarification of the novel technologies involved throughout; none used the extra blank cards supplied to write their own descriptions. Although the task was to select descriptions that matched their understanding of the design after looking at all three boards, some participants chose to lay descriptor cards on different boards, giving a finer granularity of feedback. In this instance, descriptions tended towards the non-affective terms such as 'product', 'smart', and 'hi-tech' on the specification board, reflected contextualisation on the story board with terms such as 'familiar', 'resonant'

and ‘approachable’ selected, and focused on meaning in response to the concept board, using terms such as ‘made to last’, ‘heirloom’, ‘in touch’ and ‘keepsake’. Finally, all participants when asked to place descriptor cards on the physical prototype, used exclusively soft and positive terminology – ‘engaging’, ‘authentic’, ‘friendly’, ‘personal’, ‘craft’, and even ‘cute’. The verbal protocols collected to a large extent supported the expected outcomes, and underlined the importance of the physical prototype for embodying sensorial design elements. In general discussion after the activities, participants have sought to combine their different models of understanding into a more coherent whole, and these protocols are extremely useful to capture in attempting to understand the relationship between the two modes of perception. Issues include the effect of the embedded technology on the look and feel of the design, the handle and robustness of the blanket, on experiential aspects of the monitor (which was poorly represented on the 2D boards), and on the user’s attitude to patchwork as a particularly value-laden craft technique, as well as pragmatic issues with supplying babies’ clothes early enough to create a personalised product for the intended child. While the static scenario on the storyboard helped to contextualise the design for some participants, it is hoped that the Flash animation, when tested, will be more engaging still, and will help to bridge the cognitive and sensorial modes of understanding illustrated so far.

In evaluation of the design itself as embodying familiarity and materiality, more participants than expected displayed a positive attitude to novel technologies in personal products, and tended to trust the rigorous safety testing process they assumed would be behind any available functional product. The use of patchwork was successful in eliciting immediate recognition of traditions and domesticity, and the idea of using and keeping for posterity favourite babies’ clothes was seen to positively

connect the adult with the child through the continuation of a family narrative and shared activity. The use of patchwork was not universally popular, as the strong associations with especially gender roles in a domestic setting were seen to be politically unfashionable. The verbal protocols collected in these cases began to reveal underlying negative perceptions of craft as a whole, and craft as an aesthetic device for these users becomes a negative factor. Participants who had had disappointing experiences with craft, when their expectations of authentic experience had been let down through weak fabrics or poor fastening mechanisms, also had strong negative associations with the approach as a whole, and sought their authenticity in the effectiveness of the technology, intellectual interest and rigorous consideration of the robustness of the design. Familiarity, then, obviously cannot be assumed to be generally positive, and it is expected that the cultural probe materials, to be collected shortly, will more clearly illustrate the different attitudes to craft in this user group.

### **Future Work & Expressions of Smart Materials**

Some work remains to be done with the evaluation of the comfortBlanket, most importantly the data from the cultural probes needs to be collected and analysed, and the animation needs to be tested. The project did not extend to the implementation of the design, nor could it address more longitudinal user issues and perceptions. Its success in capturing the immediate affective reactions of the 'shopping experience' should now be built on to design an iterative process of design leading to functioning prototypes which can then be tested with users over a longer period of time and in 'real' lifeworld contexts. This is the aim of the Expressions of Smart Materials project, scheduled over the next eighteen months. With the support of a residency at the Silversmithing and Jewellery department at Edinburgh College of Art, the author

is developing conceptual interactive jewellery designs that allow the combination of *Speckled Computing* with other more familiar materials. ‘Specks’ are millimetre sized sensors with wireless networking capabilities (specknet.org.uk). They can be used to sense anything from temperature to motion or light intensity, and are most powerful when arranged in networks, exchanging and passing on information to a PC or wireless network. This in turn opens up the way jewellery is worn to reinterpretation – instead of wearing discreet pieces, collections of sensing jewels can be selected by the wearer to reflect their mood and enhance their self-expression as the day or occasion demands. Metaphors are being explored from traditional jewellery whose elements are dynamic - charm bracelets for example – and new interaction experiences are expected to arise through consideration of the aesthetic of interaction itself – *slow technology* for example may be an interesting area for further exploration in this context (Hallnäs et al 2001). The networked jewellery will aim to support existing social structures by ambiently connecting a group of friends. A group of six users has been recruited, and an initial session held positively evaluating enamelling as an authentic technique, and land-, sea- and skylscapes as a familiar expressive starting point for the designs.

## **Conclusions**

The projects presented here highlight philosophical issues and a shift towards materiality in society in popular and academic literature. They are posing interesting problems for the evaluation of products that are at once crafted and yet computationally functional, and it remains to be seen whether a more holistic methodology can be constructed. Finally, it just remains to silence the pessimists on the future of craft – far from being compromised by technology, craft is needed all the

more as people look for ways of dealing with disembodied worlds of information and experience. To contribute fully, answer its critics and debunk outdated stereotype, the craft world must take itself seriously enough to ensure that when there is discourse, it is recorded, published and disseminated in a rigorous manner. The researcher would also like to acknowledge the continuing generous support of Alison Crerar and the HCI Group at Napier University, and Dorothy Hogg at Edinburgh College of Art.

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