Scent By A Wireless Web

Jenny Tillotson PhD RCA FIoN
Central Saint Martins College of Art & Design
The University of The Arts London
The Innovation Centre, Southampton Row
London WC1B 4AP, Great Britain
tel + 44 (0) 7710 808 157
j.tillotson@csm.arts.ac.uk
www.smartsecondskin.com

Summary

This paper explores Scentsory Design®, responsive clothing that go beyond current microencapsulated techniques, through the inclusion of wireless scent delivery systems that sense and respond to psychological and environmental changes in order to enhance wellbeing, avoid skin allergies and prevent insect-borne diseases.

Fashion is about displaying personal identity information. Scentsory Design® is about creating a *"scent bubble"* around the wearer, enhancing the visual message of fashion with medical, sensory and psychological 'wellbeing'

In this paper the development of a collection of responsive jewellery is described that dispenses fragrances, triggered by sensors that react to an individual's body state and the environment. The next stage of the project creates an *"emotional fashion"* collection. The paper will conclude by proposing fabric research developed in responsive clothes that offer social and therapeutic value in a desirable context i.e. clothes that reduce depression, prevent mosquito bites and replace alcohol as a new medium for the fragrance industry to sell perfume.

Keywords

- Scentsory Design®
- 'Scent Bubble'
- Emotional Fashion
- Wellbeing
- Multi-sensorial
- Microfluidics
- Lab-on-a-chip
- PsychoNeuroImmunology
- Odour Annoyance
- 'Scentient Screen'

Background

Evolving from the PhD work on 'Smart Second Skin'' at the Royal College of Art (RCA) in 1997 and BA Fashion Communication work on multi-sensorial surfaces at Central Saint Martins in 1991, this research firmly straddles the science/art boundaries, bringing together the disciplines of Analytical Chemistry, Nanotechnology, Perfumery, Electronic Engineering, Fashion/Textiles and Sensory Design.

The PhD research described a multi-sensorial approach to biomedical designs, recognising that all senses interact. In this context a 'Smart Second Skin' fabric is a membrane of micro-tubes fused together with microelectronics, yarns and microfluidics embedded in clothing elements, to create a 'wellbeing' scent delivery system that adds function to fashion and textile design. At the RCA, the research was demonstrated by an interactive installation of a fluidic fabric that 'pulsed' coloured liquid around a specific area to illustrate 'colodours': colour therapeutic scent delivery for different emotions and moods. (Figure 1).

The membrane is analogous to the body and human skin thus facilitating interaction between the two membranes, using the blood signals and bodily fluids of the human system. Clothing becomes almost living, as an internal 'pump' represents the heart of the fabric and the tubing as the nervous and respiratory system.

Figure 1. PhD 'Smart Second Skin''
(Video footage from 'The Wellness Collection' – A Science Fashion Story', RCA 1997)

Lab-on-a-chip

This study describes a selection of wearable items that invent a new method of aroma delivery, funded by an Arts & Humanities Research Council Innovation Award in 2004. In collaboration with analytical chemists Dr Gareth Jenkins and Professor Andreas Manz, pioneer of 'lab-on-a-chip' from the Institute of Analytical Sciences in Dortmund Germany, small microfluidic devices were implanted into multi-sensorial electronic brooches and bags. The items employed a small microprocessor-controlled unit capable of pulsing minute amounts of fragrance with a low percentage of alcohol, that is triggered by a time delay switch at the appropriate moment of the day, or by the body's behaviour to specific points of the body.

Microfluidics is a new technology, which involves the design and production of devices that deal with extremely small volumes of fluids. These devices can combine electrical and mechanical components down to a characteristic length scale of 1 micron. Microfluidics is the generic technology of manipulating fluids on a chip, including the integration of pumps, valves, mixers and reaction chambers that enable the fabrication of microreactors and lab-on-a-chip devices.

Other research (Eisner and Aneshansley, 1999) has identified the principles for defence mechanism in bombardier beetles that squirt predators with a high-pressure jet of boiling liquid in a rapid-fire action, and this delivery system was chosen as the main source of inspiration for the Innovation Award. Microfluidic technology, to some extent replicates the 'firing chambers' that bombardier beetles facilitate to mix their deadly poison and 'pulse' at immense speed from their tail pipes (Figure 2).

Figure 2. Bombardier Beetle. Photo courtesy of Professor Thomas Eisner Cornell University

Emotional Fashion

This paper investigates the extent to which microfluidic technology embedded in responsive jewellery and 'emotional fashion' garments can improve quality of life, not only to benefit human wellbeing through olfaction stimulation of the autonomic nervous system, but as a novel communication system to send an aroma 'message' that could be informative, protective, seductive or healing.

There is little evidence of similar electronic research to be found on a micro-scale, which seeks to remedy the limitations of current work on computerised scent-output devices suitable for installations or for custom control applications. Current examples described by Kharif (2005) include online video games by TriSenx and 'ScentStories', by Procter & Gamble whereby scent is emitted using a CD player.

Since the 1970's the textile industry has benefited from microencapsulated scented fabrics and more recently moisturising, insect repellent and anti-cellulite. However these standard techniques (a.k.a.'scratch and sniff') are not active because they are unable to detect stress and respond to other feelings that the user might be protected from (e.g. fear or sadness).

Fashion has a reason; it is a display of personal identity, primarily through strong visual cues. Scentsory Design® adds aroma to the fashion domain by creating radical new fashion properties of real benefit. The goal is to use a variety of scents as a tool to improve mental wellbeing, by embedding it in 'emotional fashion', i.e. responsive clothes that offer social and therapeutic value in a desirable fashion context.

The basis for Scentsory Design® is supported by research from Vernet-Murray et al., (1999) who have demonstrated how olfactory substances are capable of increasing an individual's wellbeing through changes in electrical brain activity, demonstrating how scent chemicals have the power to evoke emotion. Ader, et al., (2001) supports this approach with a new branch of medicine called PsychoNeuroImmunology that studies the mind, brain and immunology system, exploring 'positive psychology' and the connection between emotional stress and the health of the physical body.

As a result it is anticipated that the properties of 'emotional fashion' will be good for all, but of special value to people susceptible to anxiety and depression. Research by Warrensburg, et al., (2003) proves that the benefits of fragrance include the balancing of the nervous system, reducing blood pressure that rises during stressful events, reducing heart rate, fear and the stress of unpleasant medical procedures e.g. MRI scans and promoting a positive mood e.g. happiness or relaxation.

By combining microfluidics with clothing elements (such as buttons) that 'pulse' liquids through a membrane constructed of micro-tubes, garments could stimulate the adrenal cortex and boost therapeutic qualities by combining the confidence enhancing and social acceptability of fashion design with the positive psychological benefits of manipulating moods. Other research by Christensen, et al., (2003) comments that certain scents significantly benefit people who suffer from insomnia, muscle stiffness, bronchitis, poor concentration, indigestion, high blood pressure and are prone to insect bites. As a result the results of this research could also contribute to the reduction of Malaria, Yellow fever, Dengue Fever and Lyme Disease.

Method for experiments

Experiment 1: The branded brooch

The purpose was to design a 'scent-on-a-chip' fashion accessory by fusing microfluidic components, biochemical dispenser nozzles, and scent reservoirs that dispense airborne nano-litre sized droplets of scent into the air, to form a 'scent bubble' around the user or a 'micro-bubble' around the accessory in order to deliver a coded scent message to certain areas of the body (Figure 3).

The fragrance was housed in a self-contained capsule built in a brooch and activated by a switch. Further miniaturization of the device would mean that it could be manufactured in high quantities and marketed as a branded product.

Figure 3. “Scent Bubble”. Photo by Guy Hills, illustration by Wendy Latham.

The advantage of the ‘scent bubble’

The primary ethical concerns relate to the potential for odour pollution and the pulsing of chemicals into a localized area, as addressed by Hilpern (2004) who argues that fragrance can be seen as the new tobacco. However, the advantage for this research allows for the targeted delivery of minute droplets of scent that is more efficient and economic in use, focussing on intimate and personal use rather than generalized and higher volume use.

The argument for releasing perfumes in smaller quantities should apply to both environmental pollution (e.g. that which causes global warming or acid rain) and pollution, which specifically affects human health, as the overall quantities involved and the chemicals themselves would have close to zero impact on the environment (especially when you compare it to driving a car or using household detergents).

The fragrance industry are taking odour pollution seriously and addressing fragrance-sensitivity issues and negative health effects for scented products, which is a positive reason why this research could start to revolutionize the fragrance industry as it offers a new system to deliver perfume. Most 'lab-on-a-chip' papers focus upon chemical or biochemical analysis and other applications where pollution is not a significant issue. Weigl, et al., (2003) suggest that micro devices require only small volumes of sample and reagents, and produce only small amounts of waste, which can often be contained within a lab-on-a-chip device.

Experiment 2: Re-useable device

Scent-Molecule

Further versions of the branded brooch included a removable scent component inside the device so that the user could personalise it with their own scent capsule. The aroma mix uses a higher percentage of fragrance concentrate in ethanol as the microfluidic device does not require alcohol as a binder, unlike mass-market standard eau de toilette that contain 99.7% pure ethyl alcohol (Pybus and Sell 1999). In this instance the scent is inherently lighter and less likely to irritate sensitive skin.

Other applications include a drug delivery dispenser that could spray ventolin™ molecules for the prevention of asthma (Figure 4).

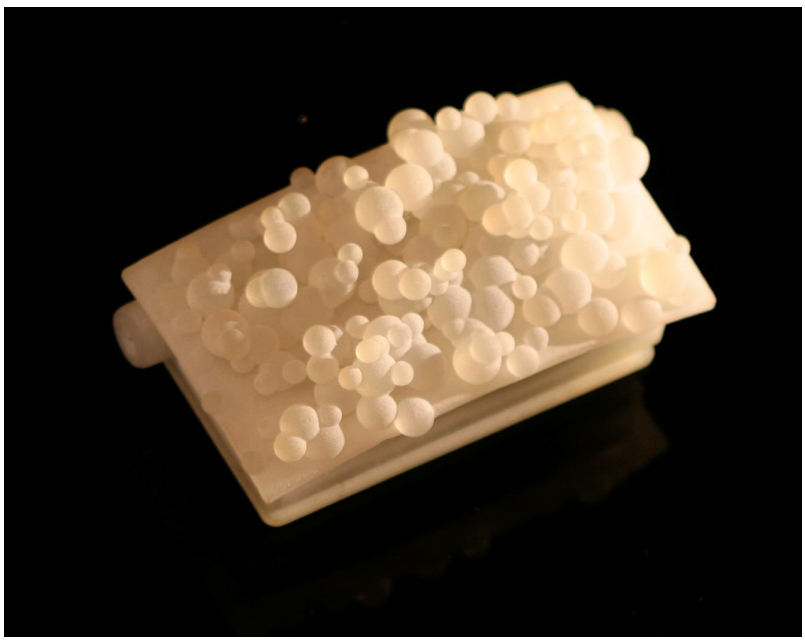

Figure 4. Scent-Molecule. Photo by Daniel Alexander. Design by Ben Hughes

Experiment 3: Communication Tool

Scent By A Wireless Web

New innovations in wireless technology have provided humans with an increased mobility in a fast-paced life. The technology created for this study has provided a new way to send a scented message over a wireless network. 'Scent Whisper' (Figure 5) links a remote sensor in a spider brooch, with a fragrance-dispensing unit in a bombardier beetle brooch, to create a jewellery set that constitute the 'wireless web''.

Figure 5 'Scent Whisper'. Photo and design by Don Baxendale.

A secret message is 'scent by a wireless web' by the user who whispers into the spider, which wirelessly transmits this message to the beetle worn by an admirer. The spider's sensor (implanted in its abdomen) records the humidity of the admirer's breath and the beetle releases a scent onto a localized area.

Scent could be used as an alternative for audio ring tones in mobile phones or as a wireless system that informs a sensory impaired user who cannot see or hear that the doorbell is ringing. Clothes could communicate the status of the stock market by releasing certain scents if the market goes up or down as suggested by the 'Dollars & Scents' 2 bit obligatory ambient stock market display research by Kaye (2001), or microphones could detect the sound frequency of mosquitoes and spray repellent towards a localised area of the body.

The proposed wireless technology could assist 'odour annoyance' in environmentally sensitive public spaces should a user enter a 'perfume-free-zone'. The device would halt perfume release as the user approaches either a person wearing a similar device, or Wellpaper™ (wireless wallpaper) in a space which communicates that he/she is allergic to certain components in perfume. (Figure 6).

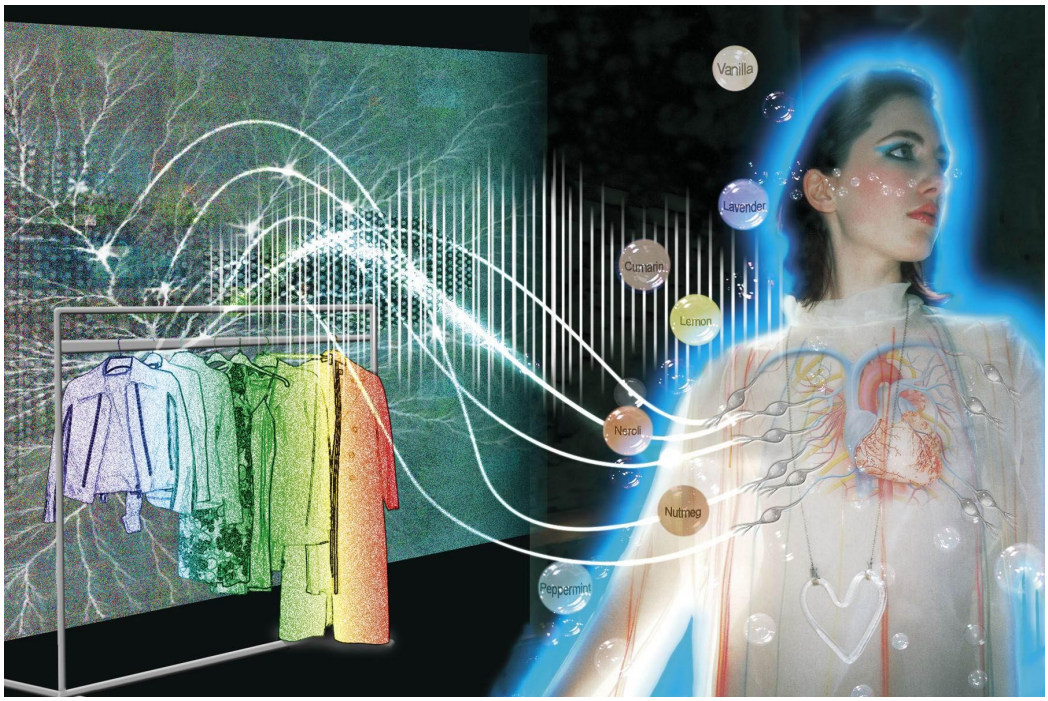

Figure 6. Wellpaper™ for Odour Annoyance. Illustration by Wendy Latham.

Experiment 4: Variable Scent Bag

For multiple scent-output, a shoulder bag was designed to deliver a variety of scents that were dispensed from separate microfluidic devices and activated by pressing three switches on the front panel of the bag (Figure 7 & 8).

Figure 7 scent bag and tubes

Figure 8. Switches for multiple scent-output
Photo by Daniel Alexander. Design by Ben Hughes

The microfluidics were powered from a control mechanism in the bag. A strip of rainbow tubing was fabricated to run alongside the tubing that delivers the scent, allowing for a colour-coding system to illustrate the various scents to improve mood states.

Scentsory Design Fabrics

This research will advance the future development and functionality of Scentsory Design® fabrics, such that they are capable of responding to biological conditions triggered by the body's physical signals. Scentsory Design® fabrics will house individual scent capsules that allow refilling at the source. The fabrics will have the capacity to 'pulse' appropriate scent quantities through microtubes that are protected in water resistant polymers and embedded in a fabric membrane, without causing intermittent waste. This allows the exact amount to be delivered in response to the users state from an embedded scent recipe palette, eliminating problems related to odour time span and creating an economical system whereby little scent is wasted.

There are many fabric applications to be developed as a result of this research, in particular clothes that act as a communication tool, whilst also offering a 'wellness aura' or a 'scentient screen' for fashion and health purposes.

The fabric research could offer three examples depending on the requirements of the user:

1. **spraying scent directly on to the skin to contribute towards psychological wellbeing**

   According to Lichtenthal (2004) the escalation of new launches: 32 in 1980 to 227 in 2003, has led to a declining growth in the fragrance market (due to the heavy competition from other gift categories), so the fragrance industry are looking at ways to upgrade and enhance the emotional experience of buying fragrance and (once again) make it an object of desire.

   We are entering a new age of perfumery that will have a radical impact on mental health. Scent has the power to evoke emotions because the olfactory sense impacts directly with the limbic system in the brain (our emotional centre). As suggested by Pickthall (2003) smells are emotional and the raw materials used to create many of them have mood-enhancing effects. Once sprayed directly onto human skin, fragrances can enhance the personality and identity of the user. Each scent smells differently from one person to the other and every scent affects a person in a different way.

   The World Health Organization Global Burden of Disease Survey (2005) estimates that by the year 2020, depression will be the illness of the age second only to heart disease. If fabrics developed for an 'emotional fashion' collection can reduce the need for traditional antidepressant routes to treatment, including the unpleasant side effects such as headaches, insomnia, sweating and agitation, then this research will have considerable social value.

Sleep disorders are extremely common. Research by Ford, et al,.(1989) suggests that 33% of the US adult population experience bouts of insomnia whilst 9-12% experience chronic insomnia. Fabrics that 'pulse' minute droplets of scent throughout the night with properties to encourage sleep could be invaluable.

2. pulsing scent through fabric surfaces and away from the body

Studies at the American Academy of Dermatology (2000) suggest that up to 10% of the American population experience a reaction to cosmetics containing alcohol when applied directly on to the skin.

The fabric proposed in this research endeavours to replace astringents that burn sensitive skin. The clothing itself will act as a new medium for the fragrance industry to sell perfume. The key, and novel advantage of the delivery system developed for the jewellery is that the fragrance obviates the need for skin contact by solvents. The direct spraying of perfume means no additional chemicals are needed either for evaporation (e.g. alcohol) or for propellant (as used in deodorant sprays).

The delivery will be in response to the users' real-time needs. i.e. activated by a variety of body sensors (increased heart rate, galvanic skin response, temperature) or sound (dance music, insect noises, high decibels), communication from other users (symbiotic response) direct user request etc.

3. **spraying scent away from the body to create an active mobile barrier**

It has been predicted by Greenwood (2005) that by 2010 half the world's population (nearly 3.5 billion people) will be living in areas where malaria is transmitted. He claims it will be at least a decade before a vaccine for the disease will be readily available and specifically emphasises the need to expand the use of existing control methods. Currently the World Health Organisation (2004) estimate that approximately 300 million people worldwide are affected by malaria, with more than 120 million clinical cases and between 1 and 1.5 million dieing from it each year. Scentsory Design® research cannot look at the treatment of malaria, but instead the disease could be prevented by repelling the mosquitoes that carry the parasite.

According to Warren (1998) female mosquitoes are attracted to human body odour and carbon dioxide in breath. Ingredients that repel mosquitoes do so by repelling them from the host (negative hedonics), by distributing their ability to find the host or by distributing their ability to feed on human flesh. A wearable 'scentient screen' (Figure 10) that repels mosquitoes could significantly reduce malaria and other airborne insect diseases by accurately targeting the release of minimal amounts of repellent, thereby removing the need to apply copious amounts of greasy lotions and sprays directly on the skin.

Figure 10 ‘Scentient Screen’. Photo by Guy Hills. Illustration by Wendy Latham.

Conclusion

The Molecule is the message

It should be clear from the evidence presented herein that this research should lead to further development and design implications in fashion, textiles, healthcare and other systems that use smell to convey information. Smell as information will become a user-friendly medium, as technology allows people to learn coded scent messages, whether it is for wellbeing, communication or simply having fun.

The jewellery results are only a “snapshots” of computerised scent-output devices and sensors that could be used in clothing. Further steps include combining controlled scent delivery with thermochromic inks to create the ‘colodours’ effect.

In the coming years, as more is discovered about olfaction science and human pheromone research, there is room for many more beneficial applications in this unknown, but exciting field of Scentsory Design®.

References

Ader, R, Felten, D.L, and Cohen, N. (2001). Psychoneuroimmunology, Third Edition. Academic Press: New York

American Academy of Dermatology (2000). Allergies: Culprit Could be in Cosmetic Bag. Accessed 3.10.2000.
http://www.newswise.com/articles/view/?id=ALLERGY.AAD

Christensen, C, John, T and Boyd, J (2003). The Benefits of Fragrances. Perfumer & Flavorist. Nov/Dec 2003; Vol.28; page 30 - 41

Eisner, T and Aneshansley D.J (1999). Spray aiming in the Bombardier Beetle: Photographic Evidence, Proceedings of the National Academy of Science, USA, 96:9705-9709, August

Ford, D.E and Kamerow, D.B. (1989). Epidemiologic Study of Sleep Disturbances and Psychiatric disorders. JAMA 1989; 262: 1479-1484

Greenwood, B (2005). 10 Years Before Malaria Vaccine Is Ready for Widespread Use. London School of Hygiene and Tropical Medicine. The Lancet Journal. 25 April

Hilper, K. (2004). Trouble in the air. Perfume is the New Tobacco. The Independent. Accessed 9.11.04.
http://news.independent.co.uk/uk/health_medical/story.jsp?story=580858

Kaye, J (2001). The Olfactory Display of Abstract Information. M.I.T Media Lab. 2001 February. Accessed 12.5.2005.
http://alice-waters.jofish.com/writing/smell.as.media.short.paper.pdf

Kharif, O. (2005). The Sweet Smell of Success. Business News online.
Accessed 18.4.05.
http://www.businessweek.com/technology/content/apr2005/tc20050418_7222_tc024.htm

Lichtenthal, P.B. (2004). British Society of Perfumery. Accessed 05/09/2004.
http://www.bsp.org.uk/wpcsum.html

Pickthall, A (2003). CPL Aromas. Society of Perfumery
Accessed 05.09.2004. http://www.bsp.org.uk/wpcsum.html

Pybus, H and Sell, S (1999). The Chemistry of Fragrances: Royal Society of Chemistry Paperbacks

The American Mosquito Control Association (2004).
Accessed 12.04.05 http://www.mosquito.org/info.php

The World Health Organization (2005). The World Health Report. Chapter 2: Burden of Mental and Behavioural Disorders: Depressive disorders.
Accessed 28.6.05. http://www.who.int/whr/2001/chapter2/en/index4.html

The World Health Organisation (2004). Division of Control of Tropical Diseases 2004. Accessed 12.3.05. http://mosquito.who.int/cmc_upload/0/000/015/372/RBMInfosheet_1.htm

Vernet-Murray E, Alaoui-Ismaili, O, Dittmar, A, Delhomme, G and Chanel, J (1999). Basic emotions induced by odourants: a new approach based on autonomic pattern results. Journal of the Autonomic Nervous System 75 page 176 – 183, 25 September

Warrenburg, S, Schwartz, Christensen, C and Wilson, W (2003). Fragrance Research : Measuring the Emotional Power of Fragrances presented to the Esomar meeting 16-18 March

Warren, C (1998). Human and Insect Olfaction Make News At Achems. The Aroma-Chology Review, The Official Publication of the Olfactory Research Fund Vol. VII No.2

Weigl, B.H, Bardell, R.L and Carbrera C.R (2003). Lab-on-a-chip for drug development review paper. Advanced Drug Delivery Review B. Elsevier Sciences BV 2002) page 349 – 377