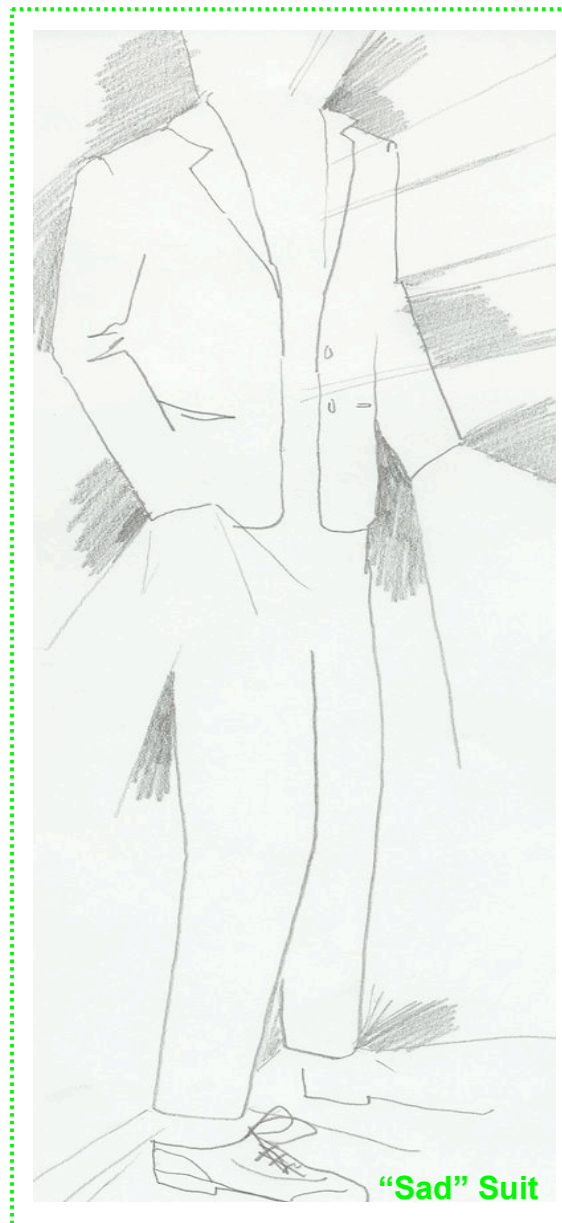


LIGHT EMITTING TEXTILES FOR FASHION & HEALTH

**A collaborative workshop hosted by the IMI and the EPSRC Smart
Textiles Network**

RIBA, 24th & 25th January 2006

WORKSHOP REPORT



Introduction

1. At the intersection of science, technology, materials and fashion, new multi-disciplinary partnerships are emerging as the basis for novel research into the application of smart textiles. Reflecting the important influences that fashion and materials can have on individual and group well-being, the workshop explored functional and psychological requirements for, as well as applications of materials in, the domains of fashion and health, and related research building blocks.
2. Light-emitting and colour-changing textiles will allow people to be creative and expressive in new ways. Fashion can also play an important role in helping to construct and communicate personal and organisational identity through display.
3. However, despite potential synergies, the relationships between light-emitting/colour-changing smart textiles, fashion and health is currently an open space for development, as is the broader application of fashion and design thinking to a range of health concerns.
4. This workshop has aimed to bring together leading researchers from many disciplines and representatives of industry. Reflecting the mandates of both IMI and the EPSRC Smart Textiles Network, the workshop also emphasised inter-disciplinarity as the cornerstone to developing and exploiting fundamental and applied research. We have also applied the theme of innovation to the workshop process with the intention of exploring new ways to facilitate across disciplines and generate a common understanding and language to enable us to work together.

Box 1 | Workshop Questions

- How can the principles of fashion and clothing be applied to health? e.g., convalescence, mental illness, emotional health.
- How could light-emitting polymer materials be fabricated onto or into fibres that could be woven into textiles, and which polymers? e.g., nanotechnology processes.
- What other technological issues might there be? E.g. sensing and processing platforms. What methods could be employed to apply fashion to a variety of healthcare concerns and issues? e.g., participative design.
- Brainstorming within three multi disciplinary sub groups (health/functionality fashion) focused upon visualising future applications

The process

5. Facilitated discussion¹ and brainstorming were central to the workshop process. Using methodologies initially explored through one of the UAL's Designing for the 21st Century projects², an external facilitator (Remko van der Lugt) supported discussion in both break out groups and plenary discussion around the emergent themes
6. The overriding aim of the initial brainstorm was to generate visions for light-emitting textiles. These visions, captured by CSM art students, provided the basis for further discussion within the three multi-disciplinary sub-groups. The groups focused upon i) health ii) functional clothing and iii) fashion. The subsequent plenary discussion attempted to map the outcomes of the sub-groups in terms of emergent research themes and questions that cut across the groups.

¹ An external facilitator was employed for the day event – providing an invaluable third party to the map

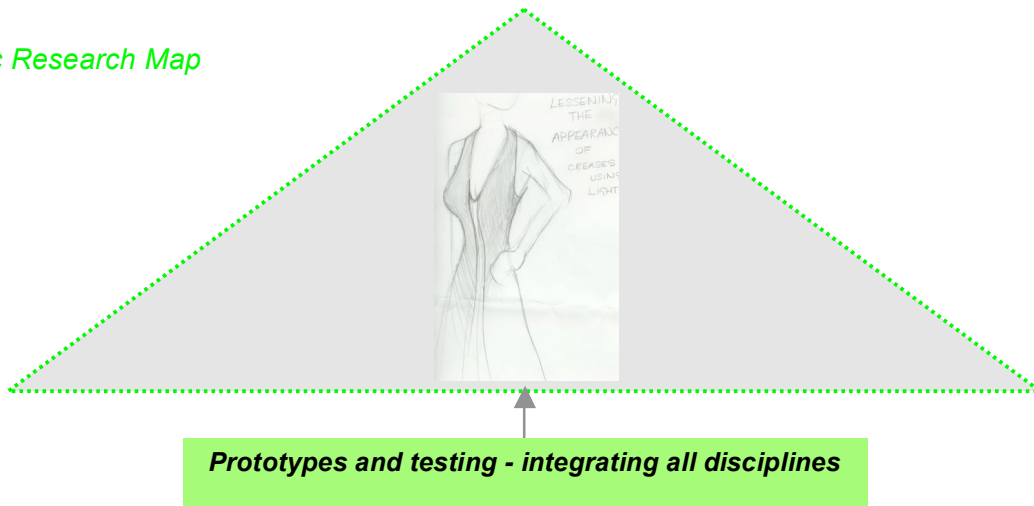
² EPSRC/AHRC Designing for the 21st Century cluster: The Emotional Wardrobe (www.emotionalwardrobe.com)

7. Exploring the “who, why, what, how” questions of future light-emitting textiles, the break- out groups brainstormed different types of applications that could be developed in social, institutional and economic scenarios. Throughout, art students sketched ideas and themes that emerged from discussions.
8. The technological dimension was a key theme that cut across the three groups, exploring how the light-emitting visions may actually be enabled in terms of fundamental science and technology. The afternoon plenary attempted to map possible collaborative research scenarios and identify the related issues and synergies between science, engineering, psychology, design and other disciplines.
9. Six research themes are identified in the following pages on the basis of the outcomes of the discussions. Further themes are possible, including those that go beyond light-emitting textiles and include a wider research agenda (see conclusion and follow-up).
10. The IMI team of four Business Development Managers, one from each of the participating Universities are committed to supporting follow-up initiatives as identified by participants, including working with academics to develop projects.

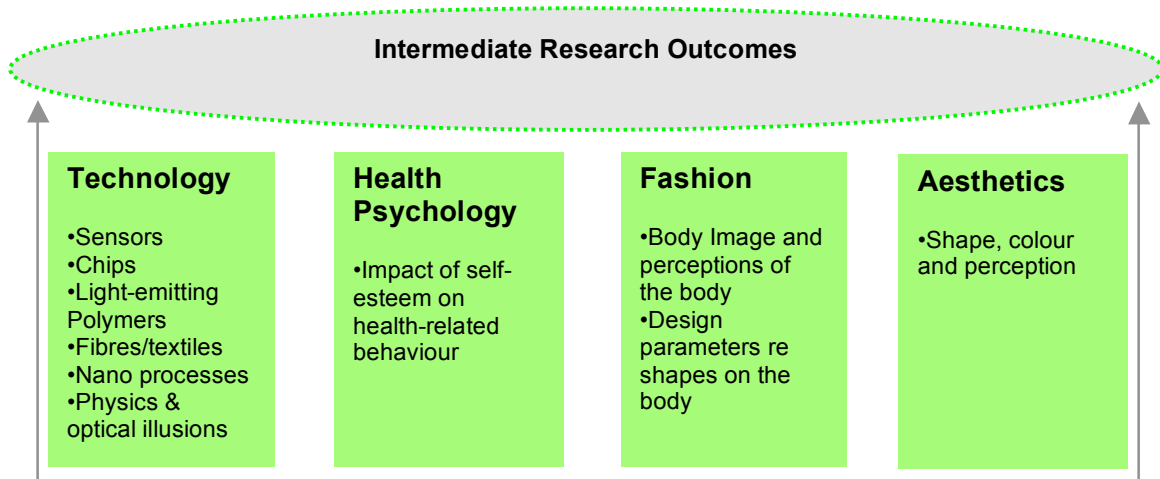
Outcomes of Brainstorm Sessions | Research Themes

11. Through brainstorming, the group generated a wide range of themes, ideas and research questions related to light-emitting and smart textiles in terms of what applications may be developed and the groups that are most likely to use them, both in fashion and health. Following the consolidation of workshop findings (Annex 1 & 3) - further effort has been given to clustering the research questions under the themes. Below is an example framework for addressing a research question.

Generic Research Map



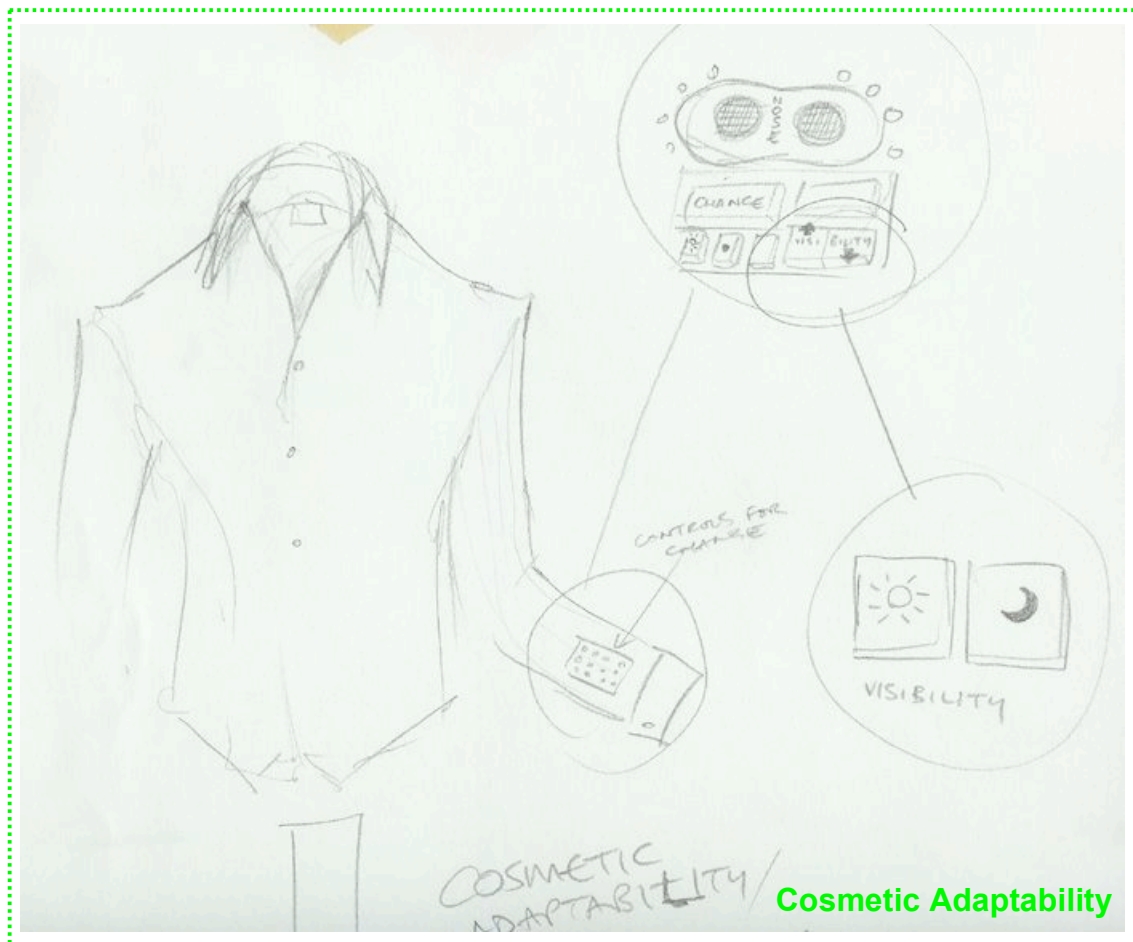
Research Question: How could established fashion design parameters be extended to dynamically changeable clothing with regard to body image, e.g., the use of optical illusions, and would that promote positive self-esteem?

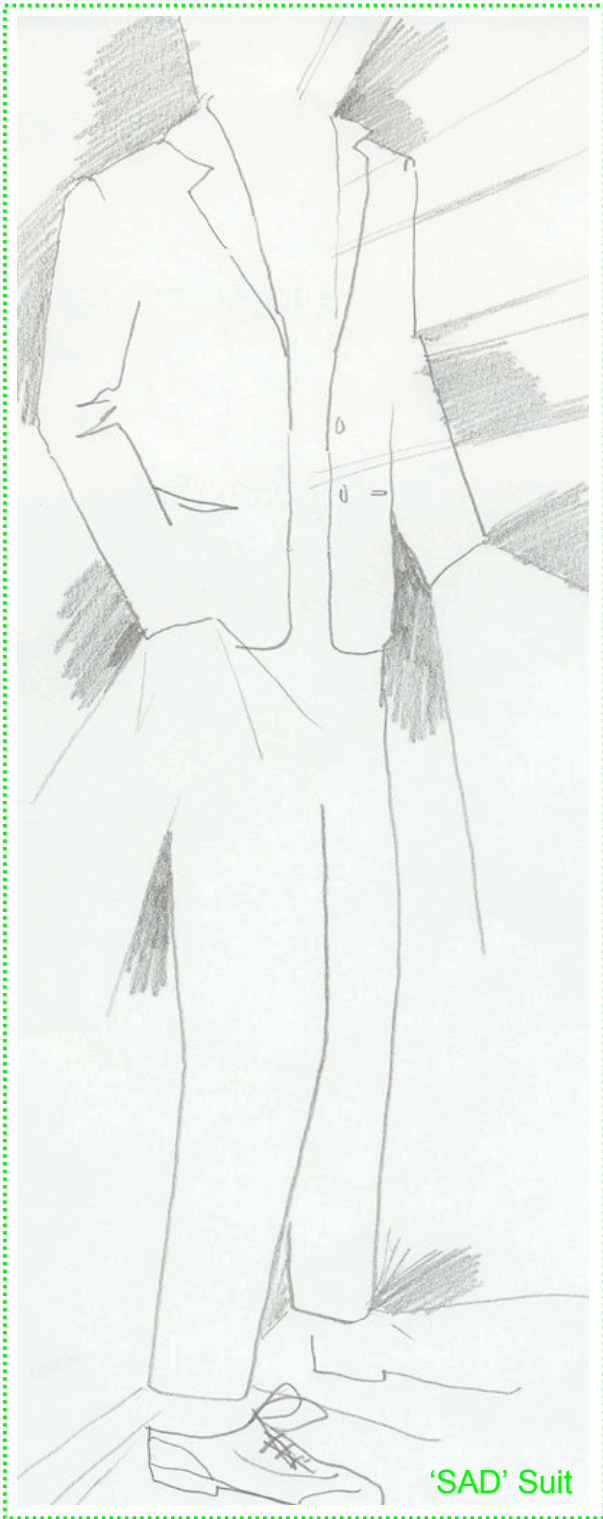


Research Theme 1 | Fashion-Health Interface

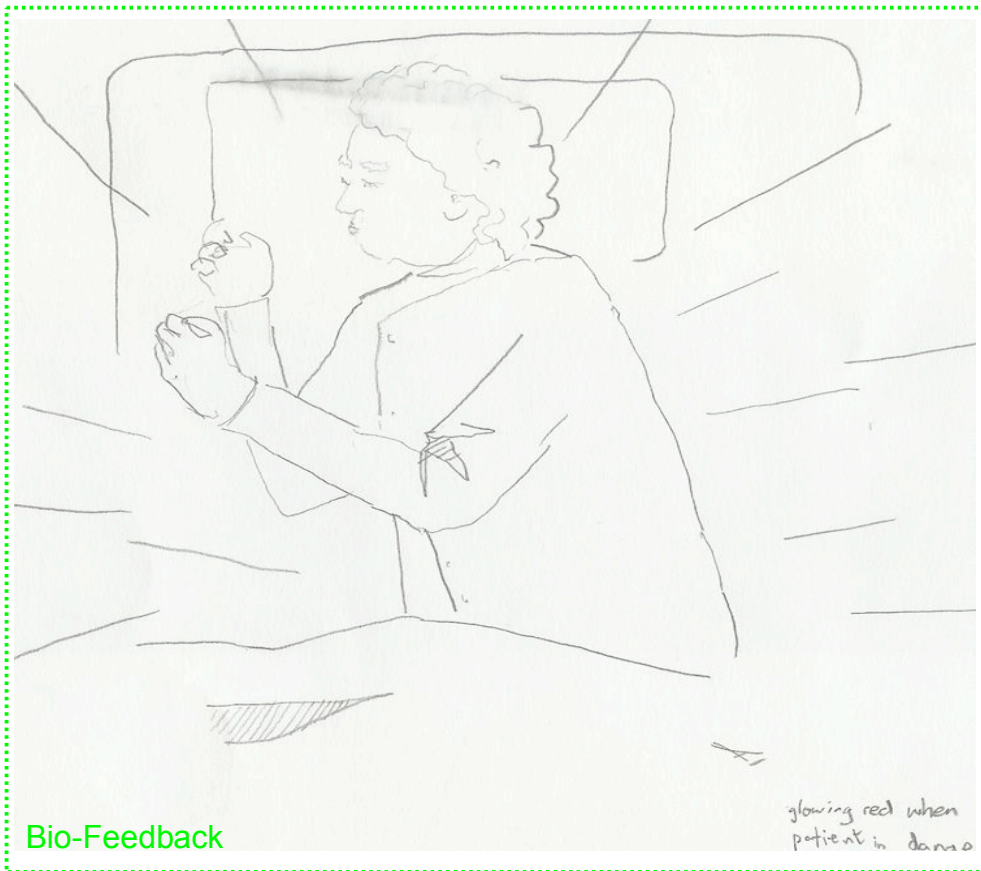
Research Questions

- Could fashion be a tool to better understand and influence/change people's behaviour in the context of health psychology?
- Could light-emitting textiles in fashion/clothing be used in conjunction with positive stimuli to modify and improve behaviour in the context of health psychology? E.g., visual rewards.
- Could dynamically changeable clothing affect your self-esteem and emotional functioning (e.g., anxiety, depression, etc)?
- Could light-emitting textiles be used as a communication tool for the sensory impaired?
- How could established fashion design parameters be extended to dynamically changeable clothing with regard to body image, e.g., the use of optical illusions, and would that promote positive self-esteem?
- Could light-emitting textiles be incorporated into clothing to stimulate individuals, and provide sensory experiences?

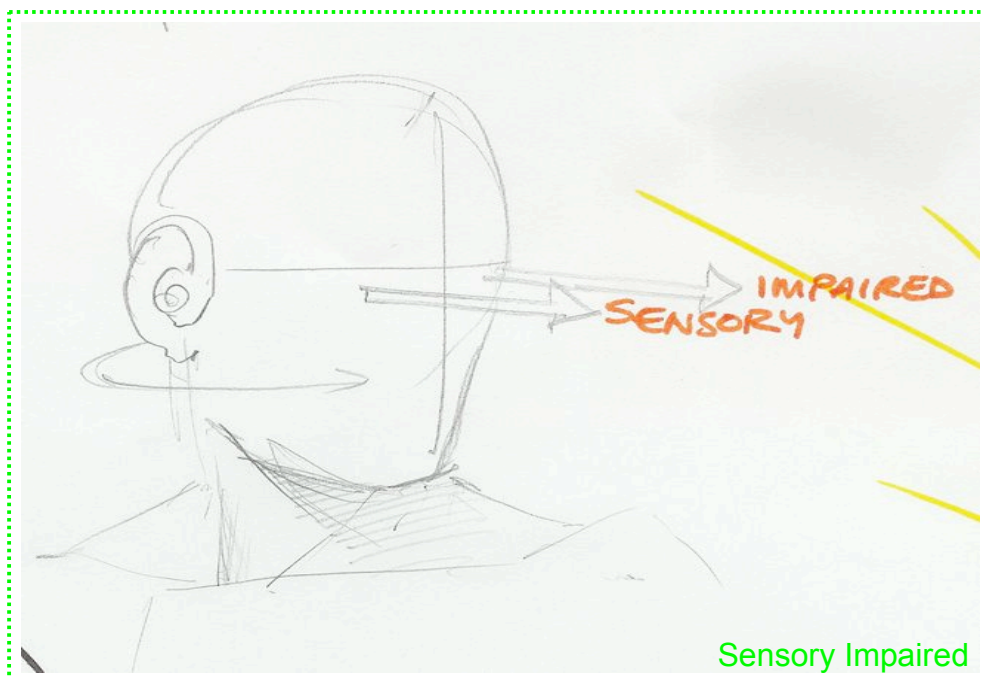




- Could light-emitting textiles in clothing be used as part of home-based diagnostics, e.g., clothing that lights up when medicine has not been taken?



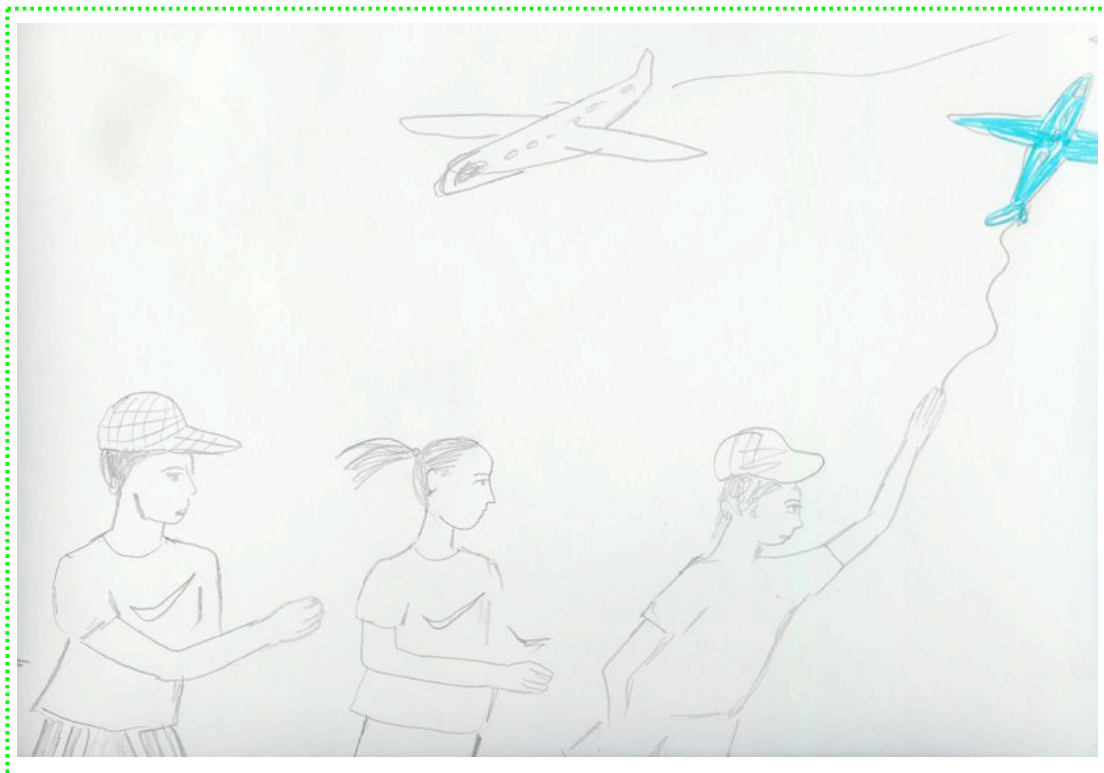
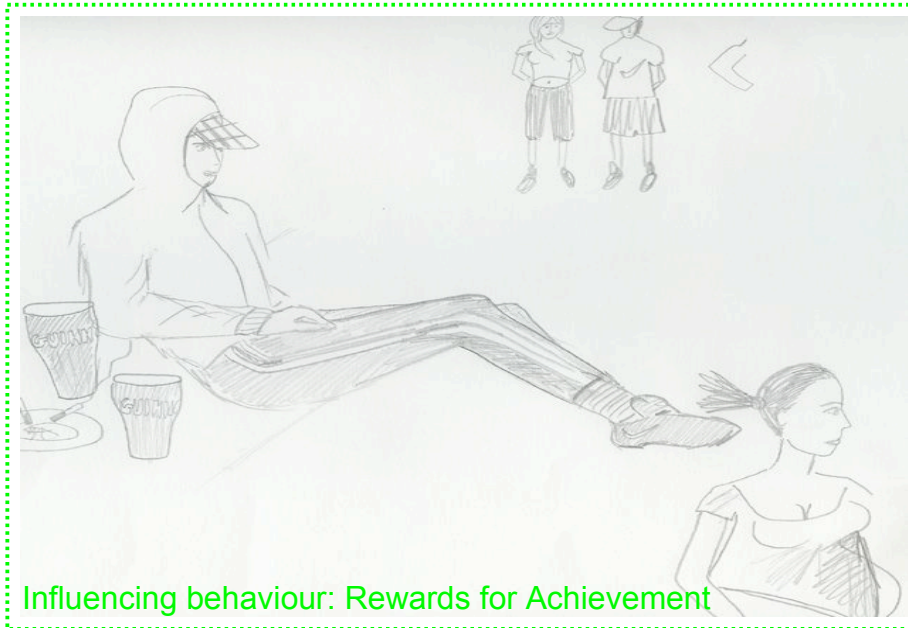
- Could light-emitting textiles in clothing play a part in communication between patient and carer, e.g., for the partially sighted?



Research Theme 2 | Sports/Functional Clothing

Research Questions

- Could light-emitting textiles in sports clothing be used as part of a monitoring and bio-feedback system?
- Is there a commercial opportunity to develop fabrics that will inform/reward leisure sports people for achievement, e.g., airmails (or other reward mechanism) for jogging 1000 metres?



Research Theme 3 | Technology and Fabrication

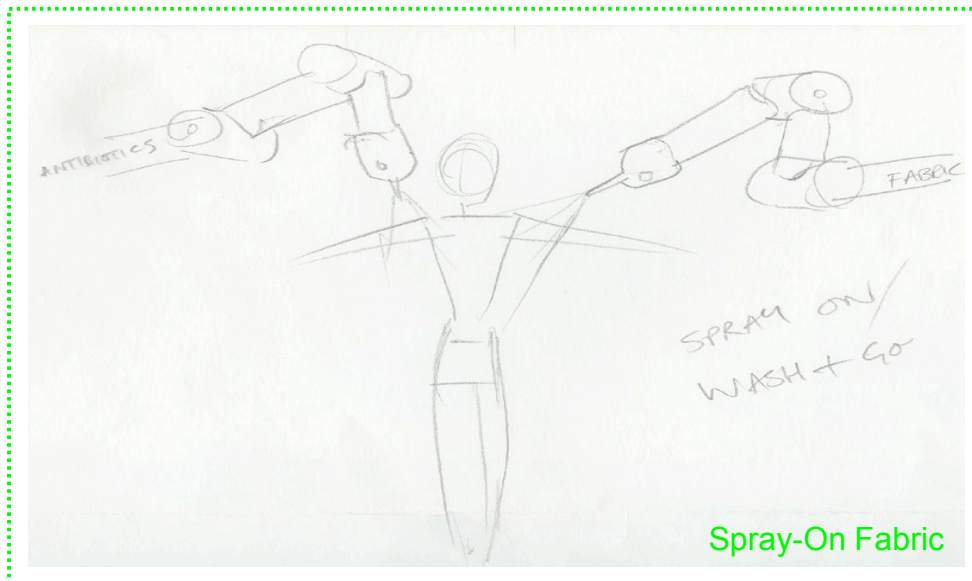
Issues that cut across the themes

Technology mapping – how can we characterise the different technologies that might be appropriate for these applications? How to divide functions of the overall system? In different domains - what functions are required?

What is required within textiles? What is required within devices? How do we interconnect?

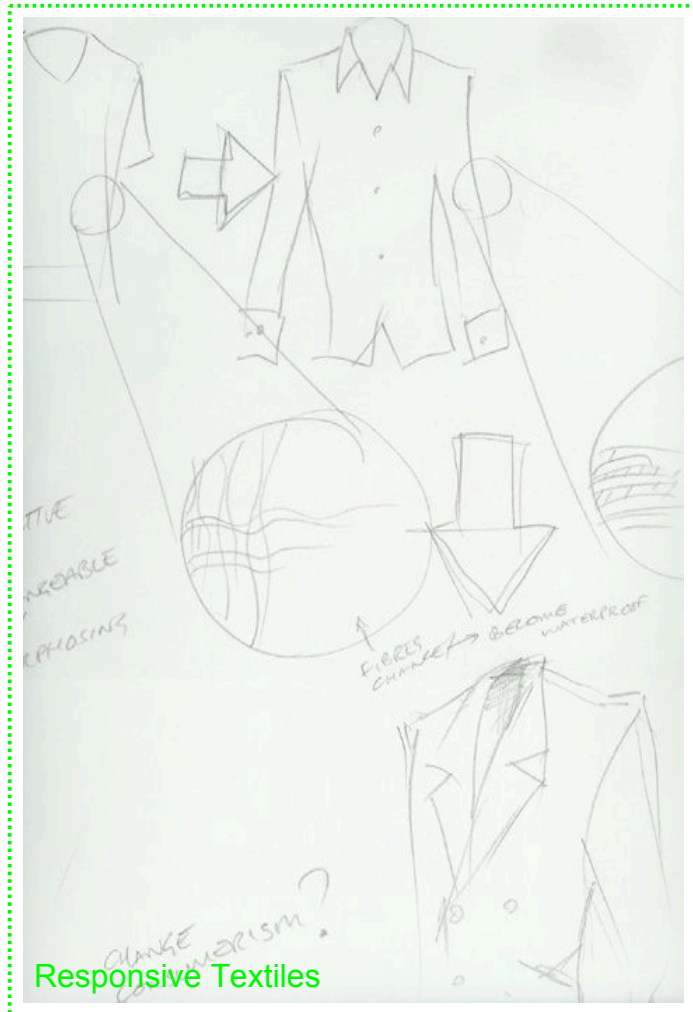
How can power be captured, stored and used?

How do we get light into textiles?

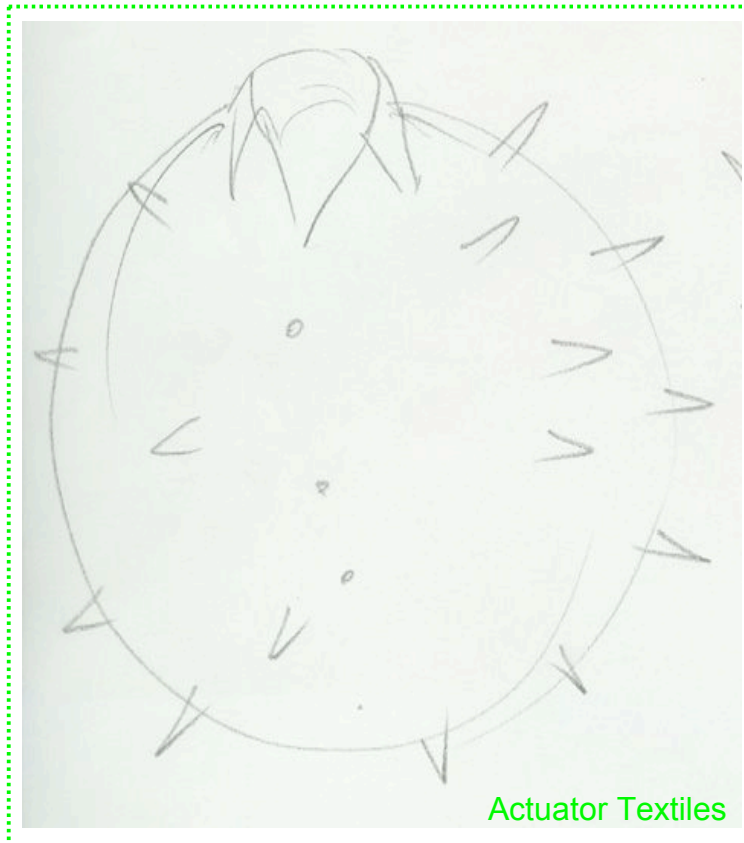


Research Questions

- Do we need LEDs all along the cloth, or can they be incorporated into clothing?
- Can we create light without electrical power (Lifetime of phosphorescence) – could movement trigger light?
- What sensors detect motion and information capture? How to transmit?
- How can textile light be visible?
- Could solar energy be captured?
- How can convergence of textiles, communication and sensor technology improve performance?
- How can clothing be an actuator?
- How can clothing provide a sense of touch?
- Can sensors detect motion?
- How can we converge textiles and communications and sensors?
- What are the advantages of distributing sensors in clothing?
- To what extent can simulation be used to evaluate applications (i.e., prototypes for ideation and user evaluation)?



Responsive Textiles

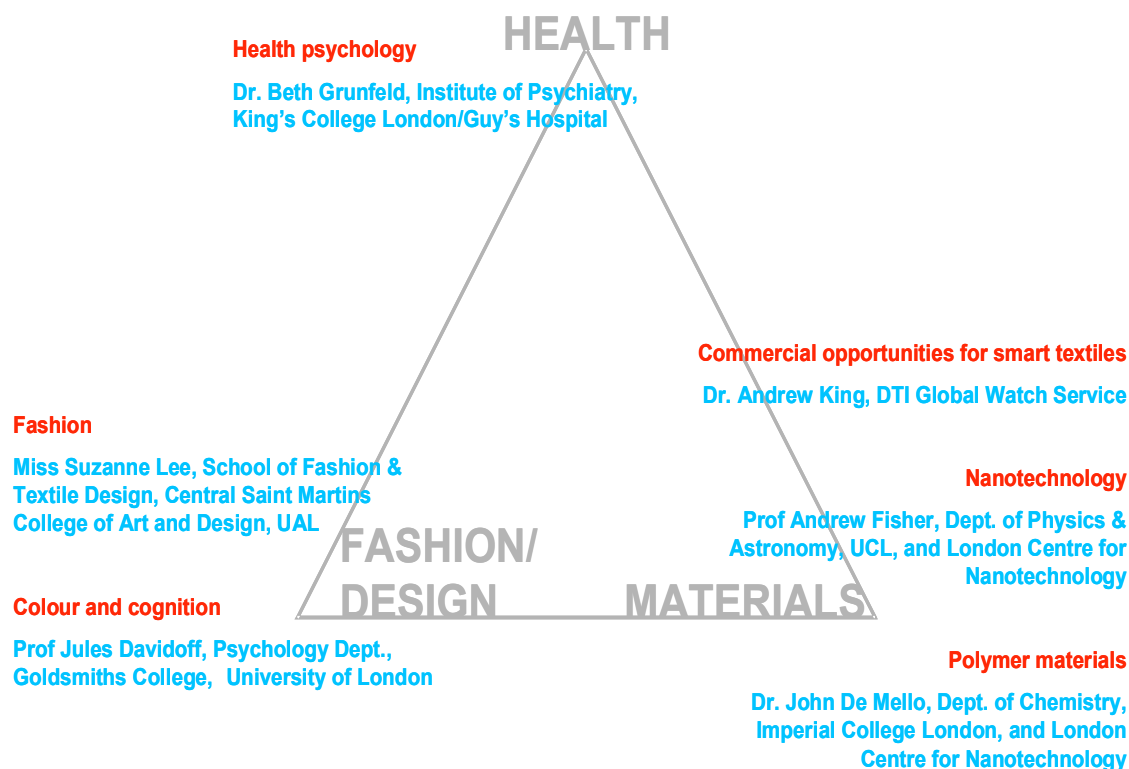


Actuator Textiles

Initial Lessons and Possible Follow-Up

Process

12. The workshop had two elements: The evening event comprised keynote speakers from fashion, psychology (health and colour), nanotechnology, materials and a wider perspective on commercial opportunities for smart textiles. A second part to the workshop took the form of a facilitated brainstorm.



13. From the perspective of the co-ordinators, the evening event fulfilled its purpose of generating interest and providing insights into areas of fashion, health and technology that may have potential synergies in terms of research and application. Central to this aim was facilitating space and time for people to engage with topics that attendees may not have engaged with before. From the coordinators, the event worked in these terms, although upon reflection the number of speakers may have been too many for the time available. Alternative formats that will be considered for the future may include fewer speakers with scope for a panel discussion.
14. The facilitated workshop on the second day explored in more detail the visions for light-emitting textiles. Following initial envisioning the sub-groups worked back into the more fundamental research areas and questions, such as those related to technology and the core disciplines necessary to achieve outcomes.

15. While generating a rich and vibrant discussion and possible research topics, it was also recognised that the agenda for the day was very ambitious in relation to the detailed outcomes anticipated (see Box 1). The facilitation and the use of drawings proved very useful as the basis for generating ideas and

Box 2 | Points for Future Facilitation

- Value of “face to face” briefing between the facilitator and organisers prior to event to help.
- Value in providing participants with a map of the day and a broad outline of expected outcomes.
- Innovative role for visualising discussion through art students to help create a common language.

promoting a shared inter– disciplinary understanding. Lessons learnt from this process will be used to further develop and refine this methodology.

16. A number of lessons learnt in the planning and execution of facilitation are identified in Box 2. Follow up consultation between with participants will provide for a wider range of views to be

identified and reported.

Strategic Issues

17. While the workshop focused upon envisioning different applications (in terms of what, how, who and why questions) other broad ranging strategic issues emerged during discussion workshop content and process.

Narrow scope of topic.

18. This view was expressed in term of the technology (light-emitting) as being very narrow in relation to alternative solutions that may provide enabling technology. While recognising that the workshop topic did focus discussion, this reflected a conscious decision (reflecting past experience of the STN network) to provide a focus for the event.

19. It is recognised that follow-up activity should provide scope for the science and technology disciplines to consider alternative technical and science-based solutions in relation to desired research outcomes. In this context it is also recognised that in some cases solutions to problems may not be technologically driven.

The research questions require further definition.

20. The primary purpose of the event was to generate insights and synergies between disciplines and map possible research outcomes and questions. The decision not to pre-define the research questions was considered as necessary to avoid limiting discussion (in terms of topics and themes). In order to develop the research themes into follow up activity it will be necessary to distil and define the research themes and questions in more detail.

Value of a holistic approach in mapping research themes and applications.

21. It was noted by several participants that future solutions for meeting social and individual wants and needs are likely to involve a broader range of disciplines/expertise than covered by the workshop e.g., architecture and interior design. One possible solution in terms of future development of the research themes will be to ensure that the broader synergies are addressed in the context of follow-up activities. The IMI can also help to facilitate this process.

Engagement with industry

22. Involvement with industry and public sector service providers (i.e. end users) at the earliest stages of scoping research themes was considered important by the organisers in terms of:

- Helping to define research themes and questions that are key in terms of the relevant sectors of the market (which they serve);
- Providing the scope for developing relationships (individual and institutional) that may form the basis for future collaboration.

23. The Business Development Managers are exploring a number of issues with reference to how best and at what point to engage with industry in the development of ideas. The following issues have been identified which could shape follow-up activities:

- *Understand and map industry drivers:* Gaining a background understanding of the main drivers for research, applications and markets can help inform the development of research themes/projects and related events such as this workshop. These background insights can be developed and disseminated in different ways including the direct involvement of Business Development Managers and utilisation of existing industry contacts.
- *Briefing (researchers/industry):* Related to the above, it may be useful for academic and industry to provide a summary background briefing on respective research competencies and priorities as the basis for an informed view as to where potential synergies may exist.
- *Relevant industry contacts* within individual corporations. These contacts may include (but not be limited to) contacts within the research departments of such companies.
- *Intellectual property:* Within the workshop it was considered inappropriate to have a predefined NDA³ signed in advance by all participants on the grounds that discussion was focused upon high-level strategic themes, and that NDAs may actually inhibit discussion. However, the organisers recognise that project development will require a more formal approach to addressing potential IP issues. As projects are formalised, IP agreements could form the basis for generating confidence in the process of collaborative research project development.

³ Non Disclosure Agreement

Conclusion and follow-up

24. The following section highlights preliminary findings. These will be reconfirmed and added to on the basis of direct follow-up with workshop participants.

- The workshop (both evening and day event) generated new contacts and facilitated a sharing of information across institutions and disciplines.
- The facilitated workshop produced many different visions for light-emitting textiles as well as a number of research themes and questions. These can provide the basis for focused follow-up activities.
- The organisers recognise that the original expectations of the workshop may have been over-ambitious in terms of identifying and prioritising projects for follow-up.
- A number of concrete lessons relating to the facilitation process have been identified (see Box 2) and will be used to inform future facilitated workshops.

Follow-up

25. The University BDM's involved with the workshop will contact their own academics/contacts following circulation of this report with the aim of having one-to one meetings to discuss the emergent themes, research questions, lessons learnt and follow up activities.

26. The BDMs will then share feed back to confirm and map which themes are areas of follow up activity academics and partners are interested in pursuing. The BDMs will then facilitate a dialogue between those groups to discuss concrete actions in the form of proposals, accessing possible funding opportunities, further networking event etc.

27. Possible areas of follow up to this workshop could include:

- Further development of research themes into research projects.
- Further networking events (IMI or and STN).
- Development of non-light-emitting themes that emerged during the workshop discussion, e.g., design and health, technology and materials, etc.
- Follow up networking with industry to map key contacts, identify needs and brief on University offering (IMI, STN).

Key Questions

What is the market going to be?
Profitability chain?
- Value
- Social
- Commercial
- Scientific

The Market

Consumer needs and benefits
Running safety
Market-dependent on technology level
Quality of information
By testing/doing
Make use of knowledge from interior design
Pet market
Education of the consumer

Health-fashion interface

Fashion as a vehicle to communicate
Fashion and health relate
Fashion as a tool
 Engagement
 Self-esteem
Common psychological factors
 Self-image
 Protection
 Aspiration
Don't look into yourself
Therapeutic
Grey UV area
Environmental colour
Feeling of adopting colour
Radiation
Potential for nurses, carers, etc
Sensory limitations home

How to rationalise the technological possibilities with fashion requirements

Flexible solar cells
Flexible materials
What kind of substrates would be acceptable?
Make good use of what's available now
Create textile-like effects
Start with accessories – fewer limitations
Examples – non-traditional fibres and textile construction methods
Emergency/accident
Runner's jacket
Automatic on/off
Power issue – how much?
Shoes/accessories

Preventative Medicine

Visual representation of biological state
Research of each part must add value on its own
Impact detection for the elderly
Tech must be acceptable as a garment, e.g., seams, piping, collars, etc
Flexible electronics

Annex 2 | Emergent Research Themes

Health

1. To explore the impact of smart textiles (sensors and light emitting) on health related behaviour i.e. can positive stimuli modify and improve behaviour?

- E.g. glowing badges triggered by meeting targets?
- Rewards for good behaviour air miles
- Sports
- Sexual health

Multi-disciplinary approach required:

- Technology what is possible
- Power
- Intelligence (rewards/triggers)
- Psychology
- Social context

2. Can we develop home based diagnostics e.g. light up when medicine not taken (e.g. diabetic)? – related question of communication with carer (light particularly important for vulnerable groups e.g. partially sighted).

- Sensors/effective computing
- Multi-disciplinary (sensors/light /product design fashion/energy/psychology)

3. Sports clothing with feedback (commercial opportunity to develop materials/fabrics that will inform/reward athletes or leisure sports people for achievement e.g. health clubs (airmails for jogging 1000 etc)

Functionality

1. How to divide functions of the overall system?

- What is required within textiles?
- What is required within devices?
- How do we interconnect?

2. Power! How to capture store and use?

3. In different domains - what functions are required?

Fashion

1. Could fashion be a tool to better understand people's behaviour, in the context of health psychology?*

2. Could dynamically changeable clothing affect your self-esteem and emotional functioning (e.g., anxiety, depression, etc)? *

3. Could light-emitting textiles be used as a communication tool for the sensory impaired? *

4. Could light-emitting textiles be incorporated into clothing to stimulate individuals, and provide sensory experiences? *

5. How could established fashion design parameters be extended to dynamically changeable clothing, with regard to body image, e.g., the use of optical illusions? *

6. Is there a relationship between visual/colour and tactility (with regard to sensory experience and stimulation)?

7. To what extent can simulation be used to evaluate applications (i.e., prototypes for ideation and user evaluation)?

8. How can light-emitting textiles be used to change people's in a health context? And how can we evaluate that change?

9. Technology mapping – how can we characterise the different technologies that might be appropriate for these applications?

10. How do we design these concepts or systems so that they are appropriable by the user?

Annex 3 | Notes from the Sub Groups

Issues

Globalisation
 Interactivity
 Power
 Economic
 Cost effective/economic
 Too narrow topic area
 Healing hospitals (holistic)
 Fit with Governments agenda (also in funding).
 Alienation (will tech help or re-enforce)
 Rebrand Health*
 Quality of service provided*

Who

Elderly/vulnerable
 Young
 Shift workers
 Doctors and nurses
 Carers in the community*

Why

Out sourcing (communicating information across long distances)
 Bio-feedback*****
 Cost effective *
 Fashion*
 Security
 Early warning
 - Vulnerable groups
 - Chronic illness e.g. diabetes
 - People alone in the community
 Modification of behaviour
 - Lifestyle
 - Sports
 - Showing off
 Wellness****Health
 Promotion**+-
 Need****
 Reducing stigma*
 Reduce stress**

What

Functional Clothing**
 Clothing Feedback e.g.
 Reward for exercise**
 Jewellery
 Accessories
 Shoes
 Wearable light box
 Furniture
 Socks
 EM protective
 Bandages
 Textiles for clothing
 Textiles for Interiors
 Badges
 Environment/space*
 Healing hospital (holistic)*

HEALTH

How

Material
 Power*
 Holistic approach (i.e. textiles in a broader context in space)
 Light-emitting
 Sensors
 Feedback
 Existing technology and new technology
 (Constraint and a potential)
 - 'Fitness miles'

* Represent those points prioritised by the group

ISSUES

- Sensors more important than light?
- Layers of questions.
- Intrusiveness of sensors (size and impact on clothing etc.
- People more interested in devices – why tech in clothes.
- System of textiles and devices?
- Who owns data captured
- Is data secure, private?
- Reliability (cost/functionality)
- Enabling creativity by wearer
- Preventative care (UK very focused upon sick).

WHO

- Sports (targets and motivation)
- Babies – enhance communication (measure how they are feeling)
- Safety workers
- Livestock (finding lost livestock)
- Military
- Safety – hill walkers
- Clean room workers (sterile env)
- Young
- User communities
- Elderly (health and diagnostic)
- Stephen Hawking

WHAT

- Uniforms that can change depending on situation.
- Eliminate shadows –never look creased.
- Diet and Clothing (monitor diet/individual tolerances/help to tailor diet)
- Speech bubble –enhancing communication of those who can't speak –translators..
- MRSA clothing
- Improve manufacturing – lining up - automation.
- Bio-metric lighting- early warning identifying and communicating warning – skin measurements.
- Sterilization via UV light (is it possible to clear clothing).
- Text to t-shirt
- Particulate extraction and chemical absorption
- Heat control (radiation and convection)
- Panic alarm (beacon e.g. extreme sports)
- Monitoring environment – to self.
- Auto strait jackets.
- Colour changing football shirt
- Driving –alcohol – reactive steering wheel

WHERE

Buildings
Africa
Urban/village
Home dressmaking (customization)
Sport
Buildings (materials in buildings)

FUNCTIONAL CLOTHING

WHY

Lightweight
Functionality
People want to be healthy
Government wants people to be healthy.
Behavioural psychology
Awareness (internal/external)
Customised clothes
Aero and hydro dynamics
Sculptural –light enhancing effect
Entertainment
Performance feedback

HOW

- Provide psychological encouragement (positive behaviour).
- Enabling technology
- Power –other sources than electrical?
- Body generated power (shoes).
- Excite light emitting dyes to make them glow?
- Green fluorescent protean
- Bacterial mechanisms
- TiO2 –break down biological in UV light
- Colour without dyes (toxicity)

ISSUES

Stimulating the senses; sensory impaired

Identity – sense of self, body image, self-design, presentation of the self

Responsive – to other people's touch and presence

Spiritual – mystical, hope

Novelty – newness, fun

WHO

Techno-happy clotho-phobes

Cyclists

Children

Time-poor consumers

Patients of SAD *

Running sports

Everyone

Clubbers *

Sensory impaired *

Pets

Brides

Celestial prophecy market

Hippy/mystical projection *

Celebrities

Travellers

Football supporters

WHAT

Interactive – with people

Change transparency

Saliency

Tactility- fabric type

Time-based

Group membership

Responsive to other clothing

Use light to zap smell

Advertising

Identity *

Sensory stimulation *

Light lining of garment

Shape-change

Handbag

Feeding your soul *

Responsive *

Patterns/logos

Harmony

Spiritual *

Chameleonic

Jewellery

Gloves

Skin/tattoo

Modular accessory *

Toe caps

Contact lenses

Movement responsive

Configurable accessories

Sensory audio feedback

Camouflage

Encoded personal meanings

Wigs

Personal style

Ties

FASHION

WHY

Diversity

Aspiration

Choice

Mobility

Customisation

Exclusivity

Keep fresh

Healing – sensory

Fun *

Tribal identification

Change

Novelty *

Perceptions of body size *

Emphasis

Blending-in

Standing-out

WHERE

In church

Clubs *

Playing fields

Airplanes, etc

Parades, mardi gras, Halloween *

Home

Sensory environments

Theatre

Work/home interface

Gyms

Sport/uniforms

Annex 4 | Images

