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Communication-Wear

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Abstract *Communication-Wear* is a wearable technology clothing concept that augments the mobile phone by enabling expressive messages to be exchanged remotely, by conveying a sense of touch, and presence. It proposes to synthesise conventions and cultures of fashion with those of mobile communications, where there are shared attributes in terms of communication and expression. Using smart textiles in garment prototypes as research probes as part of an on-going iterative co-design process, we endeavoured to mobilise participants' tacit knowledge in order to gauge user perceptions on touch communication in a lab-based trial. The aim of this study was to determine whether established sensory associations people have with the tactile qualities of textiles could be used as signs and metaphors for experiences, moods, social interactions and gestures, related to interpersonal touch. The findings are used to inspire new design ideas for textile actuators for use in touch communication in successive iterations.

Keywords Smart textiles, wearable technology, touch communication, design probes.

1 Introduction

Communication-Wear is a clothing concept that augments the mobile phone by enabling expressive messages to be exchanged remotely between people, by conveying a sense/experience of touch, and presence, through sensations delivered by e-textiles. The *Communication-Wear* concept seeks to operate within, and contribute to, the emergence of a new genre in clothing and fashion, where fashion and ICT converge. Fashion/clothing and mediated communications technologies share common attributes in terms of how they enable people to construct an identity, to be expressive, to differentiate themselves, and declare their uniqueness, allowing people to form communities.

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We have taken a design-led approach in this research, as we are proposing artefacts for consumption, the framework for which is reported in a previous article [1]. Design is at the interface between technology or material and the consumer. As we are dealing specifically with wearable technology, fashion and textile design methods play a key role in our process.

Textiles have a range of tactile qualities, which textile and fashion designers have always exploited as part of their design method to engineer a look, concept, mood, etc. There are well-established descriptors for the sensory associations and *hand* qualities of textiles used in the fashion and textile industry as part of the process to select a textile for a particular clothing application. There is an industry-standard set of bi-polar attributes for fabric hand, e.g., smooth-rough, soft-crisp, cool-warm, delicate-coarse, hard-soft. These descriptors along with other references, such as colour, shape, pattern, are used by fashion and textile designers as a legitimate design method to develop seasonal design collections. These collections then become trends or genres, often becoming a part of consumer culture. Fashion is a key component of consumer culture, a cultural system of making meaning, and of making meaning precisely through what we consume; a cultural system of codes. We use aspects of material culture to map out identities for ourselves. Consumption is the only way in which such design methodology can be evaluated.

In the same way that youth groups create new languages using SMS, so a new genre of clothing that is *smart* and dynamically-changeable will need a design palette, which users can co-opt, adapt and assign their own meanings to, or make their own meanings with. This research was not about designing interactions, but about designing tools with which people can determine their own interactions, thereby gaining insight into future drivers for this kind of clothing. During the course of the *Communication-Wear* project, a range of textile actuators such as shape-changing and light-emitting textiles, were designed into jackets for use in user studies on touch communication. The team designed the garments and their textiles according to the sensory associations detailed above, and design principles, as well as drawing upon their own experiences and associations. Examples of the touch actuation included heatable textiles, textiles that change from being cool to warm upon receipt of a touch communication. A fabric that has a warm handle is generally understood to have *comforting* associations; synonyms for *warm* include having or displaying warmth or affection, passionate, friendly and responsive, caring, fond, tender. A designer would start devising a fashion collection with a concept board that communicated its *mood* on a visual and tactile level. If a key component of the collection was a *warm* mood, the designer would include swatches of fabric that were warm to the touch and had a warm aesthetic, a warm colour palette, as well as images or photographs, which communicated a sense of *warm*. The selection of these swatches and images would be informed by established cultural understandings of them, as well as the designer's experience of them. The author employed a heatable textile as a means to engender these feelings in a person when receiving touch messages. In a way we used the prototypes as a research probe as a means to create conditions in which participants could experience, play and dream, possibly gauging a deeper level of knowledge or tacit knowledge about user's desires, preferences and behaviours, as well as the way the product or experience makes them feel. Our approach aims to gain insight into what some catalysts and drivers of future consumer fashion wearable technology that permits touch communication might be, and to explore methods to design *smart* clothing that is active and dynamically changeable, which people can appropriate. In order to do this we have conducted a series of studies using probes to gain insight into how people might appropriate the functionality and create their own meanings through visual, aesthetic, and/or tactile codes, much like they do today with their own clothing. The aim of the user studies was to determine whether established sensory associations people have with the tactile qualities of textiles could be used as signs and metaphors for experiences, moods, social interactions and gestures, related to interpersonal touch. We wanted to observe whether our cultural system of codes can be mapped to touch, and by building on that, if people spontaneously form their own codes for communication.

2 Prototype technology platform

The initial stages of development of the technology platform of the prototype have been reported in a separate article [2]. Each garment comprises textile sensors and actuators, and a circuit board with a Bluetooth dongle. Communication of touch messages takes place between garments via Bluetooth. Users were able to send hug, left arm, and right arm touch actions. Users send touch messages by gesturing them.

Fig 1 Development work on placement of gesture sensor.

Textile gesture (mechanical stretch) sensors were located on the upper back where the arm joins the trunk of the body, in order to capture self-hug actions.

Touch sensors were situated on the lower parts of the sleeves, i.e., upper part of the lower arm [3].

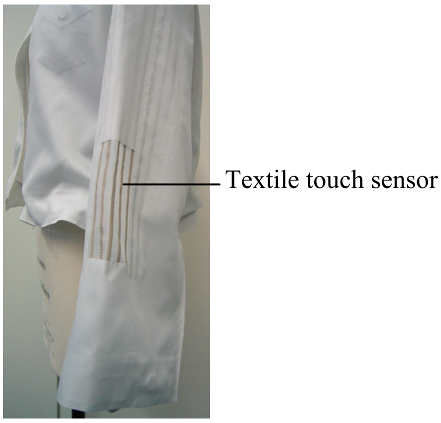

Fig 2 Touch sensor on outside of sleeve.

Galvanic Skin Response (GSR) sensors were also introduced. The GSR took the form of textile electrodes integrated into a semi-glove configuration at the end of the sleeve in the garment, which wrapped around the index and second finger. It should be noted that GSR can detect levels of arousal; it cannot detect emotion on its own, but would need to be complemented with other sensor readings such as respiration, heart rate, etc.

Actuation of *hug* messages took place via the generation of a warming sensation using heatable textiles, symbolising the warming sensation felt when touched by another person. The heat pads were located in the upper back of the jacket (on the shoulder blades). When a hug or embrace gesture is sent, the heat pads in the back of the jacket heat up. This choice was informed by the methodology detailed earlier.

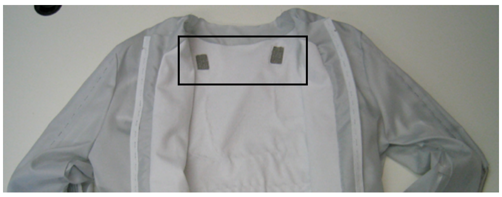

Fig 3 Black box denotes heatable textile sections.

A tactile actuator that attempted to simulate a *stroking* on the arms sensation was engineered using shape memory alloy wire together with a pleated fabric insert. This pleated insert was located on the inside of the lower part of the sleeve, so that it would slide against the topside of the lower part of the arm. A silk-like fabric was chosen that would deliver a smooth, light tickling sensation. The placement of these actuators is informed by Argyle's 'vocabulary of touch' [4], which is based on research into interpersonal touch points on the body. During our research we also looked at the issue of self-touching, e.g., self-hugging and stroking one's arms.

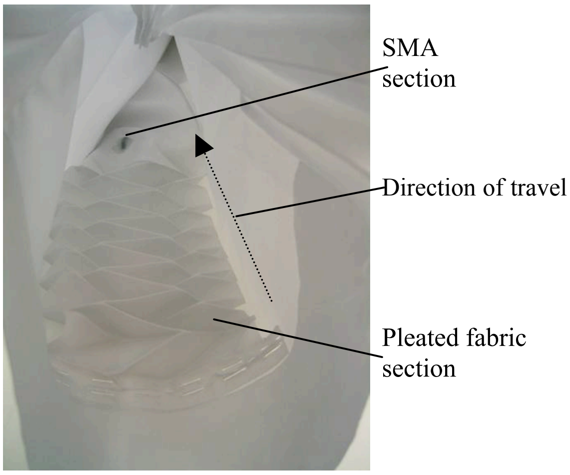

Fig 4 Inside sleeve, pleat is pulled up the sleeve by the SMA

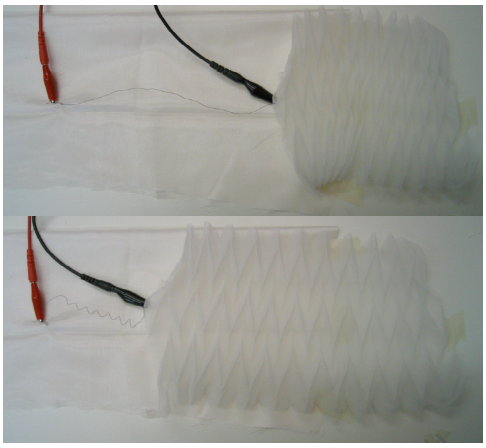

Fig 5 Development work on stroke actuator.

Fibre-optics were engineered into the garment on the underside of the sleeves. A bright LED was attached to one end of a bundle of fibre optics. Physiological arousal, as detected by the GSR sensors, was relayed to the partner by light being emitted from the fibre-optic section.

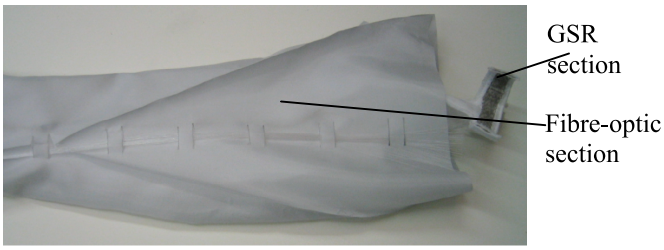

Fig 6 Underside of sleeve detail.

All electronic textiles used in this prototype were produced using a weaving process and silver-coated nylon yarn. The electronic fabric used for the GSR was also used for the heatable textiles. This fabric was comprised of a cotton warp and a stretch lycra plyed with silver-coated nylon yarn weft. The stretch characteristic of lycra produced a pile fabric, causing the conductive yarn to pucker. As this fabric has a low resistance, it performed well as a heating element, with resistance being fairly uniform across it. A textile comprised of conductive strips was used as a connector, and attached to two sides of the heatable fabric. This pile characteristic also gave the fabric both a warm handle and a warm aesthetic, contributing to the semiotic reading of it. This fabric worked well as an electrode due to its low resistance. The electrodes allow measurement of the resistance of skin, i.e., skin conductivity. As the electrode was stretched around the finger, its resistance altered very little. Due to this characteristic, the fabric as somewhat more forgiving of hand movements, thereby reducing the risk of it giving false GSR readings. The velvety tactile quality of this pile fabric increased the level of contact with the skin, and made this contact more reliable due its ability to be compressed, as opposed to a flat smooth surface. The GSR fabric measures skin conductivity over time.

The mechanical stretch sensor or gesture sensor was woven using carbon and lycra yarns in the weft, cotton yarns in the warp. We are unable to talk about this further due to current investigations into whether or not this fabric is patentable.

We used a commercially available rip stop nylon fabric that comprises continuous stripes of conductive pathways down its length. We engineered these stripes to act as a touch sensor through skin conductivity. The stripes are open circuit; when fingers touch two stripes they allow a small current to flow, which can be sensed by the circuit board.

Each garment contained a circuit board. On this circuit board was a PIC micro-controller for processing which was connected to an RS 232 Bluetooth dongle. Also in each jacket was a Sony camcorder (7.2 volt) re-chargeable battery. The touch sensor was connected to the circuit board using a Darlington pair transistors. The gesture or mechanical stretch sensor was connected in a potential divider formation with a digital potentiometer, and the resulting voltage was buffered by an op-amp. Switching-on of LEDs, SMA and the heatable textiles actuators was done by MOS transistors. The PIC processes 'events' or touch messages. The PIC responds to a large difference in value of GSR over a short period of time; for the stretch sensor the PIC is looking for a particular set value of stretch; and in terms of the touch sensor, the PIC senses a small flow of current. Once the PIC observes these 'events', it is prompted to send a character to the Bluetooth dongle, which then relays the character to the Bluetooth dongle in the other jacket. The PIC in the other jacket then triggers the appropriate actuation.

Thus, a subject by hugging themselves and stretching the mechanical stretch sensors was able to deliver a warming sensation to the upper back of the partner. An arm stroke by the sender was received as pleated fabric being drawn up the arm. Physiological arousal, as detected by the GSR sensors, was relayed to the partner by light being emitted from the fibre-optic section. The purpose of the GSR was to see whether receiving touch messages aroused the participants.

The lining of the garment was comprised of a stretch fabric, so that the heatable textiles would sit firmly on the upper back.

The outer shell of the jacket was comprised of a silk-like polyester fabric. The sleeves were designed in such a way as to allow the pleat insert inside to slide up the arm without being hindered. An outer pleated section on the sleeve allowed extra fabric to be engineered in order to permit this movement.

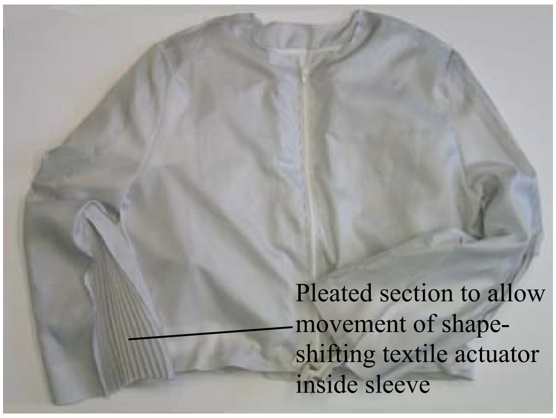

Fig 7 Outer shell of jacket.

3 User feedback

This study elicited user feedback with respect to smart textiles and clothing: To determine whether established sensory associations people have with the tactile qualities of textiles could be used as signs and metaphors for technology mediated experiences, moods, social interactions and gestures, related to interpersonal touch. We generated insights and inspiration for new design ideas around touch communication, and representation, simulation of touch gestures. In an iterative design exercise, we integrated design recommendations from an earlier study into the prototype used in this current study. The touch and gesture sensors would enable users to exchange messages through self-touching. GSR can detect levels of arousal, which yielded interesting results as a kind of *subliminal* messaging, in comparison to the apparent *control* of touch and gesture sensors. The GSR sensor linked to a light-emitting textile actuator was undoubtedly favoured by most of the study pairs, as they liked the idea of feelings being communicated. The GSR represented an interesting difference to the touch and gesture sensors to participants, in that it is automatic and uncontrollable. Even though people can engage in self-touching, which is also unconscious (and can be viewed as mimed acts of being touched by someone else, and possibly indicating a desire or need to be touched), perhaps participants were not aware that the other sensors could be just as subliminal.

Participants generally liked the idea of being able to communicate feelings, particularly through GSR. Many of them suggested that this type of communication seemed like a natural progression. The heatable textiles were understood and seemed to correlate with about half of the participants' perceptions of touch. As in the first study, the tactile sensation of pressure corresponded with people's associations of touch. But we have gained some insights into the potential use of the sensory qualities of textiles in representing intimate communication. What we can conclude is that communication is personal, but just like writing, there is a need for a universal language of sensations that people can configure to make multiple meanings. It can't be underestimated that we are at the beginning of exploration in designing for smart clothing. As textile technology progresses, more options become available with which to fashion new types of sensations and aesthetics. But right now the actuator technology is still in its infancy, which means we, as designers, have to be creative in order to engineer sensations.

4 Conclusion

We have designed and produced a wearable technology clothing concept that augments mobile communication by the inclusion of a touch function. We have developed smart or electronics textiles to produce a smart textile system. We have used these garments in an exploratory user study as part of an on-going iterative and participatory design process in the *Communication-Wear* programme. We adopted an experimental design approach in that we're using prototypes as research *probes,* and using the language of our material culture, as the focus for this research. We have generated data that suggests how people might use this kind of touch communication to support or complement their current communication practices. We have also started to explore people's sensory associations of touch in order to gain inspiration for new designs for the actuation of touch communication, as a precursor to incorporating a mobile phone platform in the next study.

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