FACTORS UNDERLYING FABRIC PERCEPTION

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'Words and images behave in different ways. A picture of a miniskirt performs a different function than the naming of it. Barthes suggest that words make the image "intelligible: [that] it is not the object but the name that creates desire (Barthes 1990) ... Orality implies community. Not only do we dress up; we talk about it' [1]

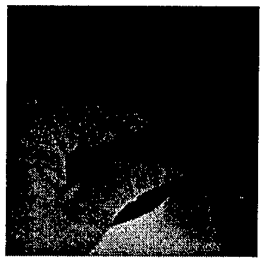
Abstract. The above suggests *'oral texture'* as a method of communication or *'ideal and emotive novelisation'*, a utopian standard of image and self-transformation, set by the fashion, textiles and lifestyle perception makers. It is a system that has been used to sell or seduce magazines (imagery and supporting text) to the reader (wearer) since the late 19th Century and blurred into the realms of retail sales and marketing, especially on-line. Society understands and indulges in this method of aesthetic communication, and for women, it is meant to represent *'women's mass culture'*. [Naomi Wolf][1]

This paper describes two fabric-touch experiments where the term *'oral texture'* applies in the collection of adjectives and metaphors (fabric perceptions). The purpose of this study was to qualitatively record subjective responses to familiar fabrics, using a Repertory Grid (factor analysis) model [2], to preliminary establish subjective and objective responses to fabrics, and through analysis, the factors underlying fabric perception and discrimination between fabric 'types'.

10 fabrics were selected. Each subject evaluated fabrics using their index finger in a forward and backward motion, with visual observation. The experiment was carried out in three phases. The first experiment was used as a Pilot Study. Data was assembled from 1 experienced textile/fashion professional/academic. The second round of data was assembled from 20 female subjects who are currently 1st year fashion and textile design students. Through the experience of the pilot experiment, it was found that these qualitative responses were split into two categories, 1. Surface Texture and, 2. Emotional/Cognitive/Mood associations. After analysis, principal factors for each category evolved. These factors were then labelled. Results are summarised and discussed.

Using the "experiment" experience, the students were than asked to select their own fabric of choice and evaluate it in a similar manner (this was not limited to evaluation by index finger, as the experimenter was not present. After discussion it was found that the method of multiple finger pinch, as illustrated in Figure 1 was primarily used, it being the most natural method of touch next to 'touch-stroke' (see Figure 9) [3]. Qualitative data was collected, as before. They were then asked to visually respond in a "virtual" manner by creating a "mood board" using Adobe PhotoShop (a combination of selective imagery related to texture, colour and style, evoking emotion and memory). This work is also discussed and some examples are shown later on in the paper.

Figure 1. Finger Pinch



1. Introduction

1.1 Background

When a person runs their finger across the surface of a fabric, or when we travel out on a shopping trip for clothing where we engage in a selection process that involves touching and trying on clothing, a complex multi-sensory, emotional and cognitive experience takes place. A memory is stirred, an emotion, feeling and association is evoked and a decision is made, an impression becomes embossed in the mind. When we shop for clothes for example, this eruption of activity extends itself into a manifestation of building and development of the 'self'. Decisions and motivations are based on anticipated reality of preference, personality, emotion and moods, for audience or non-audience participation.

In terms of fabric/texture, clothing/fashion perception and virtual technologies, little has been established that sufficiently deals with this complex relationship. Within the realms of technology, it is easy to be misguided. Human factors can become disguised or blurred into generalisation or unimportance when ideally, a complementary strategy; a human-centred system is necessary that combines novel, therapeutic and logical variables. A system that involves textiles and fashion, will rely heavily on emotion, motivation, creativity, abstract and illogical input (human). *"People excel at qualitative considerations, machines at quantitative ones. As a result, for people, decisions are flexible because they follow qualitative as well as quantitative assessment, modified by special circumstances and context. For*

the machine, decisions are consistent, based upon quantitative evaluation of numerically specified, context-free variables. Which is to be preferred? Neither: we need both". [4] If the machine can learn as we do, see as we do, feel as we do then the bridge between people vs. machines can be broken and their role as 'assistant' be reconciled with.

The emphasis of this research is in the early development of a valuable tool that eventually retailers, designers and consumers should all potentially benefit from.

1.2 Methods and Analysis

The repertory grid theory has been used successfully to study consumer behaviour. "Kelly (1955) proposed that people act on the basis of specific hypotheses, or expectations, concerning the functioning of their environment, i.e. people are assumed to be 'scientists', developing hypotheses concerning the best course of action to take in a given situation" [2]. This has been labelled a "mental model" [2], processes through which people evaluate their own surroundings and products and who possess different levels of experience and expertise. The theory is based on the assumption that people focus on positive and negative or reward and punishment aspects for any given experience. In terms of fabric perception we will say the 'opposites', however in terms of subjective emotion we may also say positive or negative. The theory was labelled "personal construct theory" [2]. A method of 'triads' is used to collect data. On this occasion for example, the experimenter presented 10 different fabrics (product) where the individual had to select three fabrics at a time, decide which two were the most similar and describe why they differed from the third. This was performed in rotation until all possible combinations had been covered (10). For example if you have a fine silk, a velvet and a leather it could be said that the silk and the velvet are the pair, both being incredibly smooth, soft, silky, reflective, glossy and somewhat oily to touch. The leather, even though it is smooth is different, it feels moist, matty and spongy to the touch. In terms of emotion/cognitive/other, the velvet and the silk could be seen as feminine, gentle, sensuous, thoughts of beauty, weddings, and party dresses, majestic happiness, decadence, gothic styles and old dusty houses spring to mind, whereas the leather could be deemed as masculine, sexual, feelings of power, fetishism, being tough, strong, possessing animal instincts, cowboys, the night, it can be deemed somewhat threatening - leather clothing, bohemia and wild rock chic's attitudes, and a sense fearlessness when worn, see Figure 2, below [5].

Figure 2.

'There's no doubting that leather represents masculinity and that's what our girls want (regardless of their sex)' (Robert Stoller, Observing the Erotic Imagination, 1985 [6]
'Leather still emerges with a tough, give-'em-hell attitude, which should satisfy the Thelma and Louise in every woman...' (Anna Wintour, Vogue, September 1991) [1]

Principal components analysis, a multivariate analysis technique, (originated by Pearson, 1901 and developed by Hotelling – 1933) [7] was used here. Given a set of observed uncorrelated (unrelated) variables the data was reduced down to the underlying dimensions based on total variation, providing fewer variables or correlated 'principal components' to examine and be used as an objective data source.

1.3 Fabric and Clothing/Fashion Perceptions

One of Lederman's reasons for why our knowledge of touch has not significantly developed as rapidly as our visual sense is, *"there is a general reluctance in our society to discuss touch-related matters".* [8] Vision seemingly dominates our attention whereas touch can therefore be seen as a private and complex emotional and cognitive experience, especially when anticipating, seeing and feeling the skin / body in touch with fabric via clothing (image creation), a *'second skin'.* [9] Encased within our clothing, unconsciously or consciously our individual arrays of texture, colour, design and style choices act as a metaphor for the self affecting our behaviour, emotion and moods, levels of motivation, self esteem/confidence representing itself as a visual and tactile mirror of the self, of our society and culture. [10]

Through history, for example in the early 19th Century England, the textures favoured at that time, *' indicated, for men, both natural (Greek) man and virtue; for women, childish frailty'.*

'Wool: National pride, simplicity, modern revision of classicism, cult of nature; matte texture is tantamount to smooth skin and natural virtue (Sir John Reynold's objection to Michelangelo's "play of light over rich texture" that inspired sensuality); mallability allows it to be molded to a man's curves; moral strength.
Broadcloth (on women): Androgyny
Wood: Natural man, modern craftsmanship
Leather: National pride, shiny foot-fetish fodder, naturalism
Cotton: Colonial acquisition
Silk: Exotic / innocent (depending on how it is woven) for women; for men, outdated, Rocco, wrinkling, light-reflecting focus on artifice rather than on nature

Muslim (white, for women): Waifish innocence; ditto bouncing hair[11]

However, *'In her study on fetish clothing, Valerie Steele argues that since the nineteenth century there has been a slow but definite turn to the so called masculine "hard" materials, especially leather and rubber. With the beginning of the modern age, she concludes, the need for a certain materiality constantly grows, and apparently it has to fulfil a specific desire for a contact, which can only be expressed in a tactile and haptic manner'.* [6]

This desire has become somewhat unisex, especially in terms of the growth in wearing casual inspired clothing and in the development of interactive, smart fabrics and wearable computers that are promised to enhance lifestyles for convenience sake. The term 'cyborg' is fast becoming a reality.

However, the other perspective, 'fashion' based a constant change of trends, will always remain, *'To transform yourself into a Romany princess is divine – if it turns you up and puts you at your ease. But don't get lost in someone else's dream: there is enough adventure in fashion to find your own'* (1970) Diana Vreeland, Editor in Chief of Vogue, 1963-1970 [1]

1.4 Aims & Objectives

The aim is to develop a multi-modal virtual reality model that incorporates a tactile (haptic) dimension, and to satisfy and soothe the physical perceptions, responses and emotions related to motivations for wearing and selecting clothes (essentially aspects of 'the self'). Existing and developing technology has the potential to offer solutions to this problem.

There are variables associated with this hypothesis. These can be categorised as follows: fabric/texture perception and motivation, style/design perception and motivation both tied to self/self-image (personality and emotional response). [12] This study provides some insight into what motivates an individual in terms of fabric and texture and some of the social implications involved.

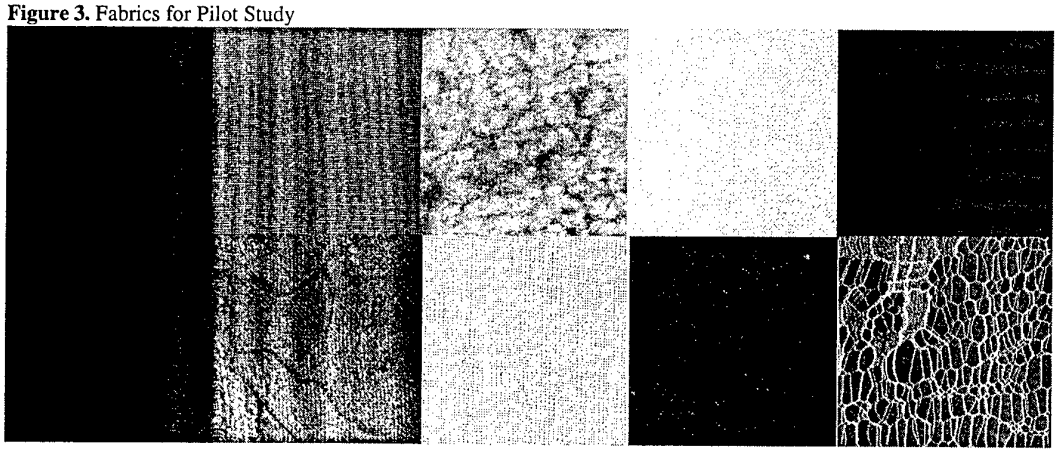
This research could be used to refine texture simulation in haptic technology and for an objective or subjective non-verbal communication system within a virtual environment

2. Methods

2.1 Pilot Experiment

Stimuli. 10 different fabrics (familiar), listed as follows, mounted flat on MDF wood measuring 3" x 3", taped down at two sides:

Figure 3. Fabrics for Pilot Study

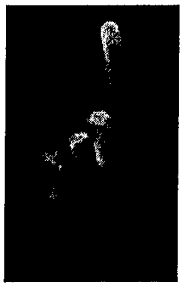


1. Fleece *(100% Polyester)*
2. Lycra *(83% Polyamide, 17% Elastane)*
3. Sheepskin
4. Silk *(100% Silk)*
5. Corduroy *(100% Cotton)*

6. Leather
7. Velvet *(100% Viscose)*
8. Irish Linen *(100% Cotton)*
9. Denim *(100% cotton)*
10. Lace *(65% Polyamide, 35% Cotton*

Subjects. 1 textile/fashion professional (academic/research).

Figure 4. Index-Finger-Stroke



Procedure. The subject was tested individually in three phases. The subject sat at a table, and using her right arm extended forward with arm resting on table. For evaluation of the fabrics presented, with visual observation, the subject was instructed to stroke using her index finger making a fist with the other fingers (Figure 4.). As outlined briefly above, using the Repetory Grid model, the 10 fabrics were presented to the subject. The subject was then asked to select three fabrics at random (triads) and to continue to do this until at least 10 different combinations had been covered. The subject had to decide which two fabrics out of the three were most alike and provide adjectives (constructs) as to how they differed from the third fabric. Seeing the same fabric in different combinations (contrasts) allows one to notice other perceptions in terms of texture and emotion/moods that may not have been considered on initial evaluation of triad combinations. The experiment took place in a university studio environment. Classic FM was playing softly in the background to open up the emotions and relax the subject. This was turned off at a later stage without any comment. Subject tended to close eyes to concentrate on 'touching' the fabrics and experienced sleepy tendencies (winter time). As expected, colour tended to add to the emotional impact even though the focus was on 'touch'.

As outlined earlier, the constructs automatically split into two categories, which described 1. Fabric Surface, and 2. Emotional/Cognitive/Mood associations. This phase took approximately 1 hour. After tabling data, in the second phase, the subject was presented with the 10 fabrics again and asked to indicate, through the same touch and visual method, agreement with an individual fabric and a construct entering a "1", if the construct was not present, they indicated this with a "0". This took approximately 35 minutes depending on how many adjectives were originally given by the individual.

A Principal Component Analysis using SPSS was run and the Construct Groupings (Factors) evolved. On a separate day, for Phase 3 of the experiment, the subject was then asked to label each factor.

The purpose of the pilot experiment was to learn how subjects would describe stimuli when given no other guidelines except a request for adjectives, consequently providing a model to follow for the main experiment.

Results. Results are summarised in Table 1 below.

Table 1. Pilot Study Factors

Fabric Surface		
Factor	**Construct Groups**	**Factor Label**
1	Resistant, soft, very soft, warm, quite warm, animal, deep pile, hairy	*Downy*
2	Changeable surface, high friction, uneven surface	*Irregular*
3	Quite silky	*Velvety*
4	Stretchy, non-rhythmic	*Flexible*
5	Spongy, grainy	*Yielding*
6	Bubbly, non-skin like	*Artificial*
7	Silky, non-gritty	*Smooth*
	Emotional/Cognitive/Moods	
1	Stimulating, very nice, caring, secure, luxurious, calming, content, sleepy	*Satisfied*
2	Teddy bears, warm	*Loving*
3	Comforting, babies, happy, non-painful, active	*Compassionate*
4	Relaxed	*Tranquil*
5	Sensual, disorganisation	*Blurred*

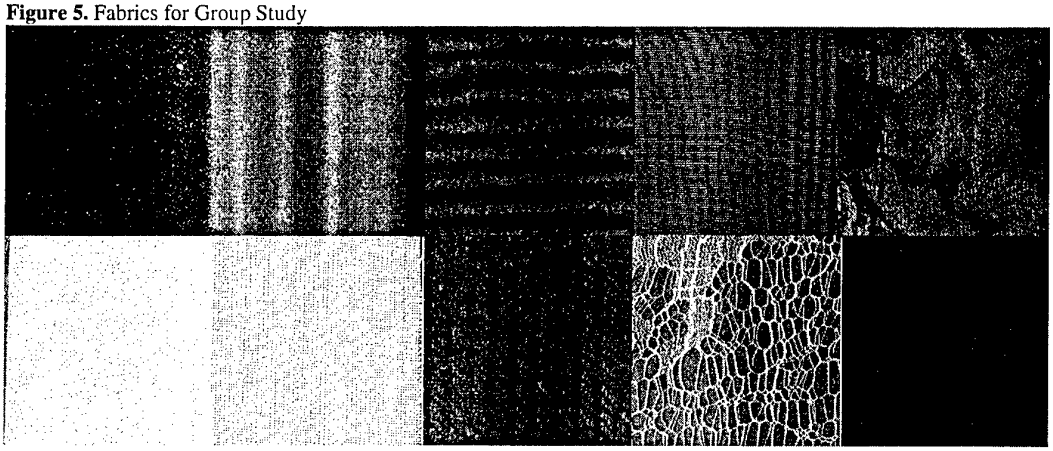
For "Emotional/Cognitive/Mood" relationships, there remained 3 constructs – Cosy, Efficient and Childish. However it is acceptable that Cosy and Childish is covered in Factor 2 and 3 and Efficient in Factor 1. The above data provides acceptable subjective results.

The main experiment, below, provides objective rather than subjective results through group analysis.

2.2 Group Study

Stimuli. 10 different fabrics (familiar), listed as follows, mounted flat on MDF wood measuring 2" x 3", taped down at two sides:

Figure 5. Fabrics for Group Study



1. Denim *(100% Cotton)*
2. Fleece *(100% Polyester)*
3. Corduroy *(100% Cotton)*
4. Lycra *(83% Polyamide, 17% Elastane)*
5. Velvet *(100% Viscose/Silk)*
6. Satin Silk *(100% Silk)*
7. Irish Linen *(100% Cotton)*
8. Tweed *(100% Wool)*
9. Lace *(65% Polyamide, 35% Cotton)*
10. Leather

Subjects. 20 female 1st Year Fashion & Textile students aged 19-23, including two mature students aged between 30-40.

Procedure. The procedure was set out as in the Pilot experiment above; the environment was a university studio setting. For Phase 3 (labelling of factors), 4 of the students and the experimenter (5) sat down in a brainstorming session to provide labels for the 'Fabric Surface' factors that evolved. The experimenter gave labels for the Emotion/Cognitive/Mood responses.

Results. Five main factors were extracted, accounting for 87.2% of the variance. Items were allocated to factors if their correlation exceeded 0.75 for Factors 1 and 2 and 0.5 for 3-5.

Results are summarised in Table's 2-6, below.

Table 2. Group Study Factors

Fabric Surface		
Factor	**Construct Groups**	**Factor Label**
1 *(34.5%)*	+Coarse, +friction, +sandpaper, +thick	Rough
	-Silky, -very soft,	Downy
	+/-	*Animal*
2 *(26.7%)*	+Stiff, +very smooth, +waterproof, +furry	Coated Seabed
	-Breathable, -clean	Fresh
	+/-	*Protective*
3 *(13.2%)*	+Natural, +tingly, +spongy, +textured	*Mossy*
4	+Gaps, +rough, +not smooth	*Coarse*

(6.8%)		
5 *(6.0%)*	+Close weave, +slippery	*Silky*
	Emotional/Cognitive/Moods	
Factor	**Construct Groups**	**Factor Label**
1 *(19.52%)*	+By a fire, +country walks, +feminine, +hats, +warm, +winter	*Sedate Warmth*
2 *(12.92%)*	+1980's, +modern	*Contemporary*
	-Ancient, -nostalgic	*Eternal Melancholy*
+/-		*Faded Familiarity*
3 *(10.48%)*	+Comfort, -bikers, -masculine, -trousers	*Male*
4 *(8.24%)*	+Cycling shorts, +dance clothing, +leotards, +swimming	*Energised*
5 *(6.67%)*	+Rich, -summer shirts	*Opulent Poise*

[+ = positive correlation, - = negative correlation]

For "Fabric Surface", Factors 1 and 2 cover the most variance. Fabrics were therefore plotted as Factor 1 against Factor 2 as follows. This offers a somewhat contemporary and stringent approach in correlating Fabric Surface responses, but an unsettling approach in terms of emotion/cognitive/mood responses:

Table 3. Factor's 1 & 2 Allocation

Fabric Surface	
Factor 1: ***Animal***	**Factor 2:** ***Protective***
Denim	Fleece
Corduroy	Lycra
Velvet	Irish Linen
Silk	Leather*
Tweed	
Lace	
Emotion/Cognitive/Moods	
Factor 1: *Sedate Warmth*	**Factor 2:** ***Faded Familiarity***
Fleece	Denim
Corduroy	Lycra
Silk	Velvet
Tweed	Irish Linen
Leather	Lace

* Leather could also come under Factor 1, but ultimately belongs in Factor 2.

Using all 5 factors, results are summarised as follows:

Table 4. Five-Factor Allocation

Fabric Surface Factors	**Fabric Type**
Animal	Corduroy, Leather
Protective	Fleece
Mossy	Tweed, Denim
Coarse	Lace
Silky	Lycra, Velvet, Satin Silk, Irish Linen
Emotion/Cognitive/Mood Factors	**Fabric Type**
Sedate Warmth	Fleece, Tweed
Faded Familiarity	Satin Silk, Lace,
Male	Corduroy, Leather
Energised	Lycra, Denim
Opulent Poise	Velvet, Irish Linen

Finally, if we merge both sets of factors together, we have the following summary:

Table 5. Combined Factors

Emotion/Cognitive/Mood	**Fabric Surface**
Sedate Warmth	*Protective*
Faded Familiarity	*Coarse*
Male	*Animal*
Energised	*Mossy*

Opulent Poise	*Silky*
Fabric	**Combined Factors**
Denim	*Energised – Mossy*
Lycra	*Energised – Mossy*
Fleece	*Sedate Warmth – Protective*
Corduroy	*Sedate Warmth – Protective*
Leather	*Male – Animal*
Velvet	*Opulent Poise – Silky*
Satin Silk	*Opulent Poise – Silky*
Irish Linen	*Opulent Poise – Silky*
Tweed	*Faded Familiarity – Coarse*
Lace	*Faded Familiarity – Coarse*

This study evaluated fabric responses and suggests that the characteristic "feel" of a given fabric depends on a particular combination of variables involving both a fabric surface and its emotion/cognitive/mood associations. If we label them separately for example categorising a fabric under a fabric surface factor only, the fabric type can differ in the emotional response. In consideration of the variables that make up a factor, by combining the factors a solution can be reached in terms of discriminative fabric perceptions.

If we then rework them in terms of words associated with the 'wearing' of these textures, i.e. the emotional self:

Table 6. Fabric vs. Factor vs. Self

Fabric	**Combined Factors**	**Emotion/Self**
Denim	*Energised – Mossy*	*Happy, young, confident, impulsive*
Lycra	*Energised – Mossy*	*Happy, young, impulsive, nervous*
Fleece	*Sedate Warmth – Protective*	*Happy, content, satisfied, reserved,*
Corduroy	*Sedate Warmth – Protective*	*Happy, content, reflective*
Leather	*Male – Animal*	*Fear, Anger, Surprise, passionate, impulsive, strength*
Velvet	*Opulent Poise – Silky*	*Happy, loving, sensual, sleek, sophisticated, extravagant, reflective, spiritual*
Satin Silk	*Opulent Poise – Silky*	*Happy, loving, sensual, reflective, sleek, sophisticated, open*
Irish Linen	*Opulent Poise – Silky*	*Happy, sensitive, reflective, spiritual, moralistic*
Tweed	*Faded Familiarity – Coarse*	*Content, reserved, isolated, moralistic, eccentric*
Lace	*Faded Familiarity – Coarse*	*Sad, sensitive/sentimental, uneasy, shy, insecure, confused, isolated, nervous*

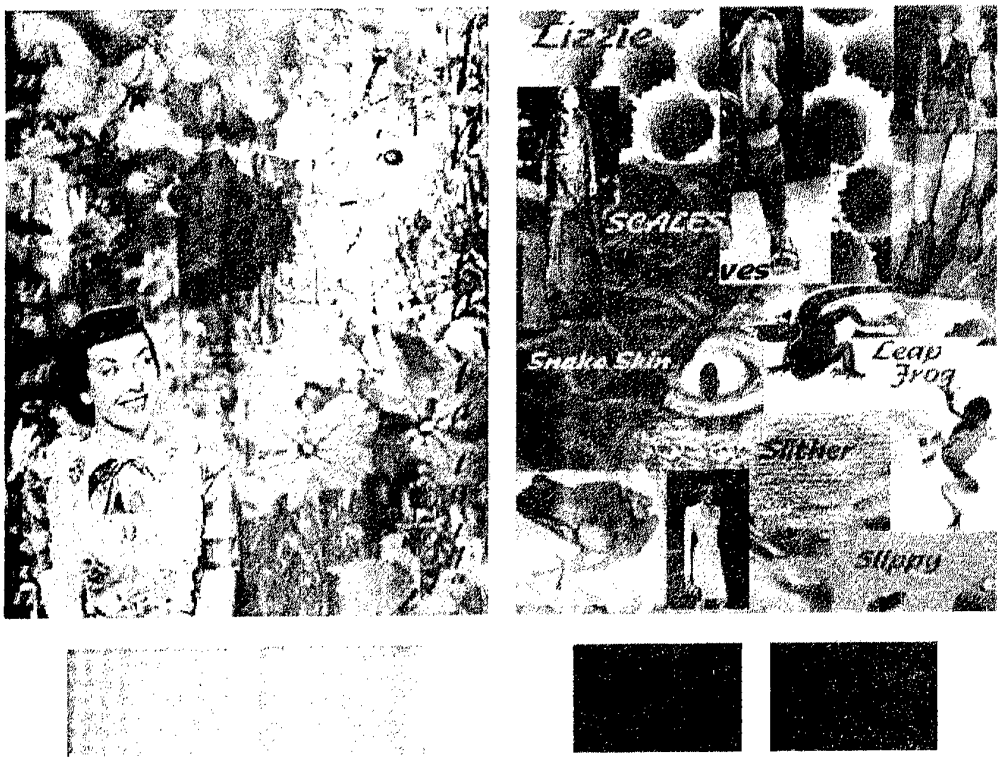
In the visual response given by students, outlined below in two examples, the relationship between fabric and the self, as above, is evident.

3. Visual Response

Mood Board Exercise. Based on the above experience, students were given a brief to select their own choice of fabric to work from and create a visual response to. The mood boards were to selectively reflect some of their responses to the physical evaluation of the fabric they selected. (These research/ideas boards are used by designers to develop design philosophies.) On completion they were then asked to label their boards with a word or words that encapsulate a visual conclusion. It should be noted that a majority of the students were previously unfamiliar with using or working with computers prior to this module. They were given 2 weeks (6 hour total module time) to complete it. It shows a variable response to different fabric qualities and on the basis of individual choice, choices they made based on curiosity or that they may relate to. It proved a positive experience in terms of introducing virtual technologies to a group that work in a particularly tactile or hands-on manner. Two examples are given below:

Figure 6. Childhood Summers
Soft, light, cool, breathable, childhood, summer, fun, nostalgic, sweets, pretty, feminine, light, home-made, homely, mothers, chintz, comfortable clothes, 1950's, kitsch, afternoon tea, games, 'my old dresses'.

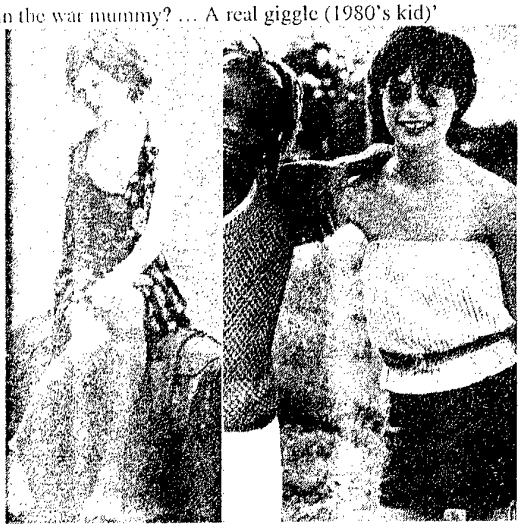
Figure 7. Slithery Lizzie
Cold, tightly woven, smooth, small grooves, slithery, wet and slippy, skin shiny, leather boots, frogs, lizards, crocodiles, sleek, sexy, punk, prostitute.



In the first story, 'Childhood Summers', the colour (pink and white), fabric type (100% Cotton) and weight (light) of the fabric, builds a visual story and a representation of a friendly character and whimsical environment. She looks delighted and in her light-hearted garden of innocence, domesticated and moralistic nostalgia. In the story of 'Slithery Lizzie' the slippery coated rigid fabric and texture has been used to create a possibly hostile character of the night that is as manipulative and corrupt, evil or just as strong, sassy, and free as a wild crocodile or snake. Yet she is also timid, mischievous and cute as a small frog.

An example of this seasons (summer) visual and oral texture messaging is as follows: *'Who can resist clothes that look like they've been stolen from your little sister's wardrobe? ... What grown-up girl doesn't yearn to don dreamy dressing-up-box clothes that their great-grandmothers might once have worn .... What did you do in the war mummy? something more whimsical for those 'let's pretend' moments ... Right now, fashion is a real giggle'*. See Figure 8, below [13]

Figure 8. 'What did you do in the war mummy? ... A real giggle (1980's kid)'



4. Handle

In terms of the ergonomic criteria for a suitable haptic device, four handle methods shown below show fabric properties evaluated by handle type. As suggested earlier, the multiple finger pinch and the touch-stroke are the most relevant. [3] However, using just the index finger has also proved acceptable.

Figure 9. Handle Techniques

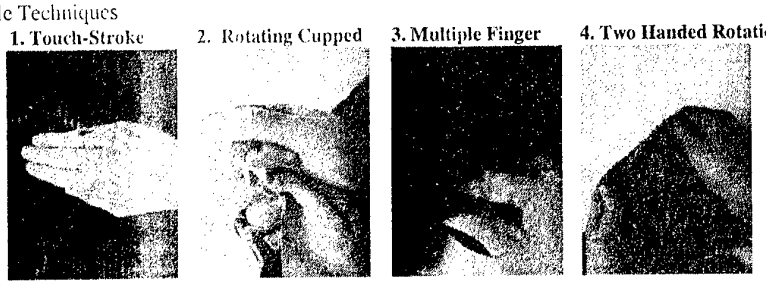


Table 7. Handle Techniques

	Handle Technique	Properties Evaluated
1	Touch-stroke	Surface quality (texture), temperature
2	Rotating Cupped Action	Stiffness, weight, temperature, comfort, overall texture, creasing
3	Multiple Finger Pinch: Rotating between the Fingers action with one hand *(thumb and1 or 2 fingers)*	Texture, stiffness, temperature, fabric structure, both sides of a fabric, friction, stretch (force-feedback)
4	Two Handed Rotation Action	Stretch, sheerness

5. Conclusions

This research introduces the delightful aspects of fabric perception through an examination of visual, touch and emotional/cognitive/mood impact. The evaluation of this multi-modal, cognitive and emotional experience, examined together, offers a reality model in the development of a vocabulary, 'oral and aesthetic texture', that could be implemented in the development of control variables for interactive communication within a virtual environment. Combined with previous work where evaluation was based on existing sensory evaluation techniques, [14] [15] both scalable and detailed analysis of fabric surface and its properties coupled with humane assessment of fabric perceptions can be established that can be used to refine haptic technology for the fashion and textiles and clothing arena.

'The hypothesis is developed that brains are designed around reward and punishment-evaluation systems, because this is the way that genes can build a complex system that will produce appropriate but flexible behaviour to increase fitness ... The reason that both emotion and motivation are treated [considered together] *is that both involve rewards and punishments as the fundamental solution of the brain for interfacing sensory systems to action-selection and execution systems.* [16] The amygdala and the orbitofrontal cortex are areas in the brain associated with emotion and motivation, stimulated by for example sensory stimuli and cognitive processing of language, memory and association. Functions of emotion are involved in the following responses: autonomic, behavioural, motivational, communication, social bonding, cognitive evaluation – events and memories, and in the storage of memories. [16] These responses are associated with clothing as with most stimuli, however, with the wearing and selection of clothing, a closer understanding to the relationship of the self can be examined.

The next phase of this research that will therefore involve evaluating and measuring psychological and neural responses to clothing and fashion, i.e. fabric in context. It is anticipated that the research, as well as providing the necessary data for translation in a virtual sense, could also provide insight into medical disorders associated with these systems in the brain.

6. References

1. Borelli, Laird O'Shea, *'Dressing Up and Talking about It: Fashion Writing in Vogue from 1968 to 1993'*, Fashion Theory, Volume 1, Issue 3, 1997
2. Baber, Chris, *'Repertory Grid Theory and its Application to Product Evaluation'*, Usability Evaluation in Industry, Jordan, Patrick W; Thomas, Bruce; Weerdmeester, Bernard A; McClelland, Ian L, Taylor & Francis Publishers, 1996

3. Dillon, Pat; Moody, Wendy; Bartlett, Rebecca; Scully, Patricia; Morgan, Roger & James Christopher, Sensing the Fabric: The Development of a Multi-Modal Device to investigate the Potential for Virtual Sensory Feedback Aligned to Textile Image', (IFFTI 3rdAnnual Conference, Fashion Directions: Visioning the Future, London College of Fashion, November, 2000).
4. Norman, D. A., The Invisible Computer, Cambridge, MA: MIT Press, 1997
5. WWW.WGSN-EDU.COM/TRENDS. April 2001
6. Steele, Valerie, Fetish: Fashion, Sex & Power. Oxford University Press, 1996
7. Lewis-Beck, Michael S., Factor Analysis & Related Techniques. International Handbooks Of Quantitative Applications In The Social Sciences. Volume 5. SAGE Publications, Toppan Publishing, London, 1994
8. Katz, David, World of Touch. Lawrence Erlbaum Associates, 1989
9. Hollander A. Seeing Through Clothes. Viking Press, New York 1979
10. "Ambivalence, and its relation to fashion and the body", Anne Boultwood and Robert Jerrard, Fashion Theory, Volume 4, Issue 3, 2000.
11. WWW/DILE/EDI/~SEDGWIC/TEXTURES/HABIT.HTM
12. Barnard, Malcolm, Fashion as Communication, Routledge. 1996.
13. Elle, Emap Elan Network Ltd, UK, May, 2001
14. Dillon, Pat; Moody, Wendy; Bartlett, Rebecca; Scully, Patricia; Morgan, Roger; James, Christopher, *'Sensing the Fabric: To simulate sensation through sensory evaluation and in response to standard acceptable properties of specific materials when viewed as a digital image'*, Haptic Human-Computer Interaction Workshop Conference Proceedings, Springer, LNCS Volume. Spring 2001
15. Civille, G; Dus, C. *'Development of Terminology to Describe the Handfeel Properties of Paper and Fabrics'*, Sensory spectrum Inc., Chatham New Jersey, 22 February 1990
16. Rolls, E. *'Precis of the Brain and Emotion'*, Behavioural Brain Science, April, 2000

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force magnitude paralleled the actual force.

Although the fit was not perfect, these preliminary results clearly validate the use of bio-mechanical models of the arm to analyze the interaction force recorded during imposed motions. Future work with a larger set of stimuli might be necessary to assess whether more complex models should be considered.

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References

[1] Chiaverini S, Siciliano B, Villani L. A survey of robot interaction control schemes with experimental comparison. *IEEE/ASME Trans Mechatronics*, 43(2):273-285, 1999.

[2] Zeng GW, Hemami A. An overview of robot force control. *Robotica*, 15(5):473-482, 1997.

[3] Desmurget M, Prablanc C, Jordan M, Jeannerod, M. Are reaching movements planned to be straight and invariant in the extrinsic space? Kinematic comparison between compliant and unconstraint motions. *Quat J Exp Pyschol. A, Hum Exp Psychol*, 52(4):981-1020, 1999.

[4] McIntyre J, Gurfinkel EV, Lipshits MI, Droulez J, Gurfinkel VS. Measurements of human force control during a constrained arm motion using a force actuated joystick. *J Neurophysiol*, 73(3):1201-22, 1995.

[5] Aisen M, Krebs I, Hogan N, McDowell F, Volpe T. The effect of robot-assisted therapy and rehabilitative training on motor recovery following stroke. *Archive of Neurology*, 54, 443-446, 1997.

[6] Craig JJ. *Introduction to Robotics, 2nd Edition.* Reading, MA:Addison-Wesley, 1986.

[7] Hairer E, Wanner G. *Solving Differential Equations - II. Stiff and differential-algebraic problems, 2nd Edition.* Springer series in Computational Mathematics, Heidelberg, Germany:Springer-Verlag, 1996.

[8] Hairer E, Norsett SP, Wanner G. *Solving Differential Equations - II. Non-stiff problems.* Springer series in Computational Mathematics, Heidelberg, Germany: Springer-Verlag, 1993.

[9] Baud-Bovy G. Pointing toward kinesthetic targets. Thesis 266, Faculty of Psychology and Educational Science, University of Geneva, unpublished doctoral dissertation, 1999.

[10] Feldman AG. Functional tuning of the nervous system with control of movement or maintenance of a steady posture. II. Controllable parameters of the muscle. *Biophys* 11:565-578, 1966.

[11] Flash T. The control of hand equilibrium trajectories in multi-joint arm movements. *Biol Cybern* 57:257-274, 1987.

[12] Gomi H, Kawato M. Equilibrium-point control hypothesis examined by measured arm stiffness during multi-joint movement. *Science*, 272(32-33):117-120, 1996.