Faces and interfaces: towards the computer mediated communication of affect

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Abstract

This paper addresses a basic issue impacting on the design of user interfaces for cooperative working: the representational transmission of affective or emotional content along computer mediated communication channels. If depictions of certain facial expressions can reliably convey emotional intent, this can be exploited in interface design to enhance and disambiguate verbally registered messages. If miscommunication is to be minimised, such representations should be culture free and reliably classifiable. A cross-cultural study (British and Mainland Chinese) is described examining the patterns of perceived affective groupings of iconic facial expression: results indicate that the basic categories are similarly interpreted across two quite different cultures. This finding implies that, in intercultural computer mediated communication, iconic representations of affective intent may be used to enhance both the content and the interpretation of computer mediated messages. Interfaces that engage users emotionally have various benefits, and the translation of this finding into interface design, and further implications are discussed.

1. Introduction

The information we receive is increasingly being mediated, processed and presented by computer. As the number of 'information workers' increases, and the complexity and richness of available information expands, the larger become the onus on the interface designer to ensure effective presentation of complex information. Furthermore, with the emergence of groupware products, and an increase in the computer-based support for team decision making, a whole raft of issues in designing interfaces for group work emerges.

Notwithstanding the great improvements in visual display of information from traditional character based interfaces through to GUIs and multimedia interfaces, with ongoing research directed towards incorporating intelligence in interfaces, we suggest that these tend to emphasise cognitive aspects of communication rather than its affective components. While this may be generally appropriate in many traditional sorts of task, for the team-based or interpersonally critical tasks that characterise computer-supported collaborative working there is a paucity of support for conveying the affective tone of a message, which, we argue, is an important determinant of its interpretation and subsequent response. Interfaces which engage users emotionally are held to have numerous benefits in making interfaces more enjoyable and natural to use, and help learning and mental growth in children (Strommen and Alexander, 1999) and perhaps other new users in less technologically literate cultures. The extra dimension of social/emotional cues enriches communication media, allowing for tailoring of messages to the frame of reference and needs of the recipient (Daft and Lengel, 1986).

In many situations the whole interpretation of a statement is qualified by the accompanying expression, or the tone of originator. Notwithstanding sophisticated video-conferencing, this is generally lost in computer-mediated situations, and with the widespread increase in team working it seems desirable to reclaim this information into the communication. In globally minded organisations however, it is surely preferable to base commonly used applications on universally shared understandings, rather than impose the values of a dominant culture. Particularly for international communication, it is important that the representations of intention or affective state through

expression are culture free, and unambiguous. Whilst video conferencing technology can be expected to supplant simulated faces in certain groupware applications, until this technology is stabilised and cheaply available, conveying affective content will remain problematic. Furthermore there is likely to remain a general requirement for conveying affective information in effective cooperative working. In the field of engineering design, Bucciarelli (1988) has noted that drawings and specifications are affected by social processes involving laughter and banter, and it is even questionable whether some designs would have been thought of without those (Ferguson, 1992). Jenkins (1993) observed the design process of teams of engineers in the UK's Engineering Design Research Centre. He noted that in design group decision making, critical information or decisions, (for or against an aspect of design) may be identified as such by facial expressions which are not recorded in written form. This can result in inappropriate activities being pursued, since there is no historical record of the group's feeling about an issue. Often the expression by itself speaks volumes, and certainly enhances and disambiguates the written word.

In this paper we first consider the general issue of the expression of emotional state and its cross cultural stability, and relate this to communication and decision making within groups. We note the effectiveness of faces as a concise representation for complex or hard to describe information. We then describe a study examining the perception of iconically-represented emotional expressions in two groups of British, and Chinese subjects and look at the patterns of association and differentiation across the two cultures. We propose that if the affective context of a message can be represented stably in a small set of icons, this information can be attached to computer mediated messages to enhance their interpretation in general situations requiring collaboration. Alternatively such a form may be used to encode the tone of a meeting or other group activity to assist later contextual interpretations of organisational memories, or for canonical encoding of photographic facial stimuli identified through image processing into a small set for storage or transmission. Given an ongoing requirement for conveying affective information through iconic representations, we consider contexts where the use of iconic information has properties that can enhance the use of verbally mediated language. We suggest that, if not definitive, our icon set is at least representative, and we would claim that for particular applications, some appropriate set can be identified, noting some possibilities in this regard. In large countries such as China, where the IT investment is currently based more around telecommunications and application sharing than on personal ownership of computers, there is a specific need for communication enhancing technologies. Linking the ergonomics of the interface with the organisational culture (Wang, 1993) is seen as one long term goal of this work, and we conclude by discussing some extensions to our basic research.

1.1 The facial expression of emotional states

As an area of psychology, face recognition is of immense theoretical and practical interest. Long before formal studies were conducted, folk theories relating facial expression to emotional states were established. The Chinese raised face reading to an art form, known as *siang mien*, a skill which still survives, and is recorded in both popular and scholarly books describing observable correspondences which betray character and temperament[1]. Charles Darwin was also interested in the relation of emotional state to facial expression, and elaborated on this in his classic book 'The expression of the emotions in man and animals, (Darwin, 1872;1965). Although Darwin's account suggested inborn human universals, anthropologists and others have noted many cultural differences which can radically modify the interpretation of expressions (see Eibl-Eibesfeldt, 1972).

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[1] Such correspondences can be extended: in Japan the radiator grilles on cars are sometimes perceived as faces expressing e.g. aggression, and car sales have been affected by this. (Equinox, - Zen on Wheels, Channel 4, 1/11/92) Italian motorists will not only refer to the grille on their favourite car as its face they'll also wax lyrical about it having a nice expression, beautiful eyes, well-formed lips, seductive lines, a beautiful presence and elegant rear... (http://www.alfa156.com/eng/az/default.htm#F, accessed September 28th 1999).

In his APA award address Paul Ekman (1993) summarises cross-cultural work on facial expression and emotion and raises numerous questions for further research. Repudiating challenges, he cites evidence for universality in facial expressions, and notes that there is no strong evidence for cross-cultural disagreement on the interpretation of fear, anger, disgust, sadness or enjoyment expressions. One challenge that can be made is that the interpretation of an expression is made by an observer acting in some context, and this cognition determines the interpretation, rather than the expression itself. The facial expressions associated with pain and with ecstasy cannot be differentiated without contextual knowledge. Tilghman's (1988) remarks are typical:

> "There have been psychological studies in which subjects were shown photographs of people's faces and asked to identify the expression or state of mind evinced. The results are invariably very mixed. In the seventeenth century the French painter Charles le Brun drew a series of faces illustrating the various emotions that painters could be called upon to represent. What is striking is that any of them could be substituted for one another without loss. What is missing is any setting or context to make the emotion determinate."

While these comments have validity, in the world of computer mediated communication where communicators are distanced from one another, some simulacrum of the meeting's feeling, or tacit context is surely better than none, especially when taken in conjunction with a verbal message. Given the deeply problematic issue of context-free interpretation, an intermediate position seems most pragmatic. Such a position would recognise that conveying 'universally understood' information is not possible using only words, and a restoration of lost context is required. Representing facial expressions may give fairly unambiguous culture-free clues to emotional state, but respecting those aspects of expression which are culture specific is also required. Verbally transmitted material requires not only integration with pictorial information, but also with the culture's psychosemantic context. Such integration has investigated by Rieber, Tzeng and Wiedmann (1989) who pursue Bateson's (1972) general question "How is it that the artifacts of one culture can have meaning or validity for critics in a different culture?" by specifically examining the forms in which information about a cross-culturally perceivable quality is encoded. Their study showed that while iconic representations tap deeper areas of emotional resonance than most verbal stimuli, there remain unique cultural patterns that affect how iconic material is perceived and evaluated.

The ability to recognise and differentiate faces and facial expressions within the same face has evolutionary and adaptational consequences, and allows for responding more sensitively than simply reacting to verbal expressions.

From the point of view of information sharing the human ability to differentiate facial expressions is remarkable: a fact that has been utilised in the design of Chernoff faces for the display of multivariate data (Chernoff, 1973). Chernoff faces allow the presentation of multifaceted complex information in a concise diagram resembling the characteristics of a human face, and by using the highly evolved ability to distinguish faces, interpreters of these diagrams can quickly identify both groupings by likeness, and significant differences between two multivariate data displays. The number of faces that can be differentiated vastly outnumbers the number of words in natural language, and due to the ability to continuously vary on several dimensions simultaneously, their potential to carry shades of meaning and to indicate attitudes critical for accurate interpretation is immense. Furthermore, since pictorial forms allow for the interrelationship among parts to be grasped along with the simultaneous perception of multifarious aspects there is an increase in efficiency of information transmission which, in Japan, has resulted in learning several times more efficient than learning in verbal form. (Maruyama, 1986). Maruyama suggests that encoding complex information in pictorial form allows businesspeople to process recorded messages more rapidly, and with reference to the combination of character parts in Classical Chinese describes a general scheme for keyboard input of "pictemes" - basic components of picture coded information systems. Keyboard interfaces based on simplifying classical idiographic characters have met popular resistance in China and Japan, and developing picture-coded representations is seen as an important extension to the often isolating and (currently) communicationally impoverished world of networked organisations.

From another angle, face recognition by computer is also undergoing a revival after 20 years (Brunelli and Poggio, 1993) and this has applications in security, criminology and other areas. The algorithms involved traditionally tend to view face recognition as part of visual processing, and consider the face purely as a geometric image to be distinguished from others. However, the features used in the model described by Brunelli and Poggio(1993) which achieved perfect recognition on their test set, are interesting. Taking anthropometric standards as initial measures, then refining them mathematically, 35 facial features are extracted. Of these, 4 concern the eyebrows' thickness and position, and 11 concern the arch of the left eyebrow. Thus almost half of the distinguishing features concern the eyebrows. The eyebrows are one of the most expressive parts of the face, and this has implications for differentiating among emotions, as Ekman (1993) has suggested.

The image analysis techniques developed in artificial vision systems have direct implications for the ergonomics of the user interface. The literature suggests that difficult or long tasks are characterised by increased grimacing and other cues to stress (Delvolve and Quiennec, 1983). Sheehy, Chapman and Forrest (1987) examine non-verbal behaviour at the computer interface using an image analysis approach to categorise detected gestures and looking behaviours along with frowns, grimaces and other facial expressions. Detecting and acting upon this information can avoid failures and suggest remedial action (Sheehy et al, 1987). In addition to facilitating the social interpretation of visually transmitted information, one implication of linking face recognition with interface design lies in the intelligent processing of information within specialised human-computer interaction. With cameras built in to faster machines, and by using intelligent automated image classification, the possibilities of conveying richly differentiated information to a machine are realistic. Research at the Science University of Tokyo has already resulted in a program that can distinguish among human expressions such as anger, surprise and fear. Intelligent applications can then be programmed to respond appropriately, and this line of work is liable to lead towards more sensitive interfaces in future computer based information systems (McKevitt and Gammack, 1996).

Against this background, we set out to investigate how context-free representations of facial expressions would be interpreted in two distinct cultures. Notwithstanding the conflicting findings in the literature regarding cultural differences, we took the view that some set of faces representative of affective states could be agreed, and in principle be transmitted to enhance communication context in collaborative working, or could be used to encode process information for a videoconference record. According to theory, which is not uncontentious, the major categories of emotional quality include principally dysphoria (fear/anxiety) and euphoria (love/happiness). Anger, sadness and disgust are postulated as other basic emotion modes, where one criterion for basic emotions is that their associated facial expressions should be panculturally recognised (Oatley and Johnson-Laird, 1987). Accordingly we chose a set of 70 schematic faces covering distinct affective states across theoretical categories, as the next section describes.

2. A cross cultural comparison of emotional expression icons

In this study we examined, across two subject groups, the similarity classifications and labelling for 70 schematic faces found on a popular poster[2]. These faces were chosen for being essentially race and gender free, and for their thorough coverage of the main theoretical categories of emotion, and other affective states. Figure 1 shows a sample of the faces used, with the original labelling.

After removing the predefined emotion labels, each face was cut out, and put on a separate card, numbered on the back for identification purposes. A dot was also placed on each card to ensure the correct orientation. Subjects were then given the cards, and asked to group them into as many

[2] The faces used are copyright by A.K. Graca and have often been handed out for feedback following management training events, or used in special education. Other uses of these icons are currently (1999) available at http://www.howdoyoufeeltoday.com/. Icons shown in figures 1 and 2 are reproduced by permission.

categories as they saw fit, labelling the category with an appropriate emotion term, then turning over the cards and recording the numbered faces in each group. Single item "groups" were permitted.

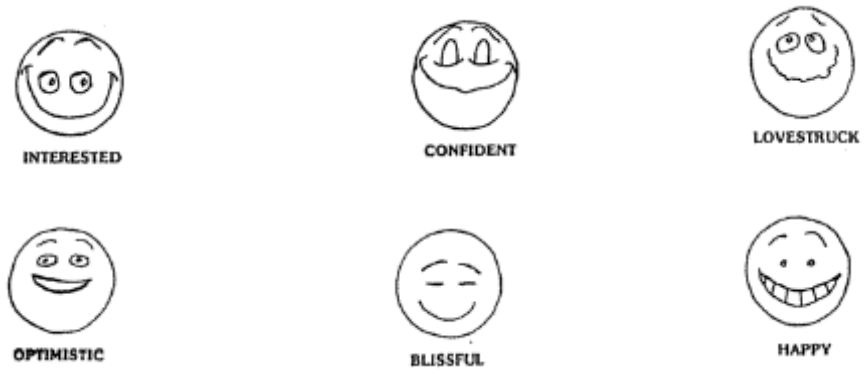

Figure 1: sample faces used in the study: these are mainly located in the "*happy*" group*

Two separate groups of subjects took part in the experiment: 42 students in the UK (median age 20) and 60 students in China (median age 22). The subjects worked individually, and recorded their own responses according to the same set of (translated) instructions.

The analysis followed a psychometric scaling approach used extensively in interface design and in summarising organisationally complex systems (McDonald and Schvaneveldt, 1987). Taking the stimuli sorted into groups, we then (across all subjects) counted the number of times items co-occurred in groups. This gave an inter-item distance coefficient reflecting similarity between item pairs, thus showing overall which expressions were similarly perceived, and consequently distinctly perceived, from others. This formed the input matrices to the Pathfinder analysis program (Schvaneveldt et al, 1985; Schvaneveldt, 1990) which was then run on the two data sets, British and Chinese. The Pathfinder algorithm produces a link weighted network showing the strongest associations in the data set, where the strength of association (shown by a numerically weighted pairwise link) reflects the relative frequency of those items' co-occurrence. The resulting Pathfinder networks (Minimal spanning tree, dominance metric, weights omitted for clarity) are shown in figures 3 and 4 respectively.

The Pathfinder analyses show, for each expression, the item perceived as most similar by each group of subjects. Where an item has more than one nearest neighbour this implies either a tie in the number of co-occurrences, or that under the dominance metric the shortest path through the data involves those particular associations. Psychologically this implies that such an item captures a central quality of those in its immediate vicinity, such as *miserable*, which has affinities with *lonely; disappointed; grieving* and *withdrawn* for both sets of subjects in a cluster which may be generally labelled as ***sad***. The relevant icons are shown in figure 2.

Figure 2: some sample faces perceived as similar across both subject groups*

* Copyright by How Do You Feel Today? Productions, Box 1085, Agoura Hills, CA 91301 USA. All rights reserved.

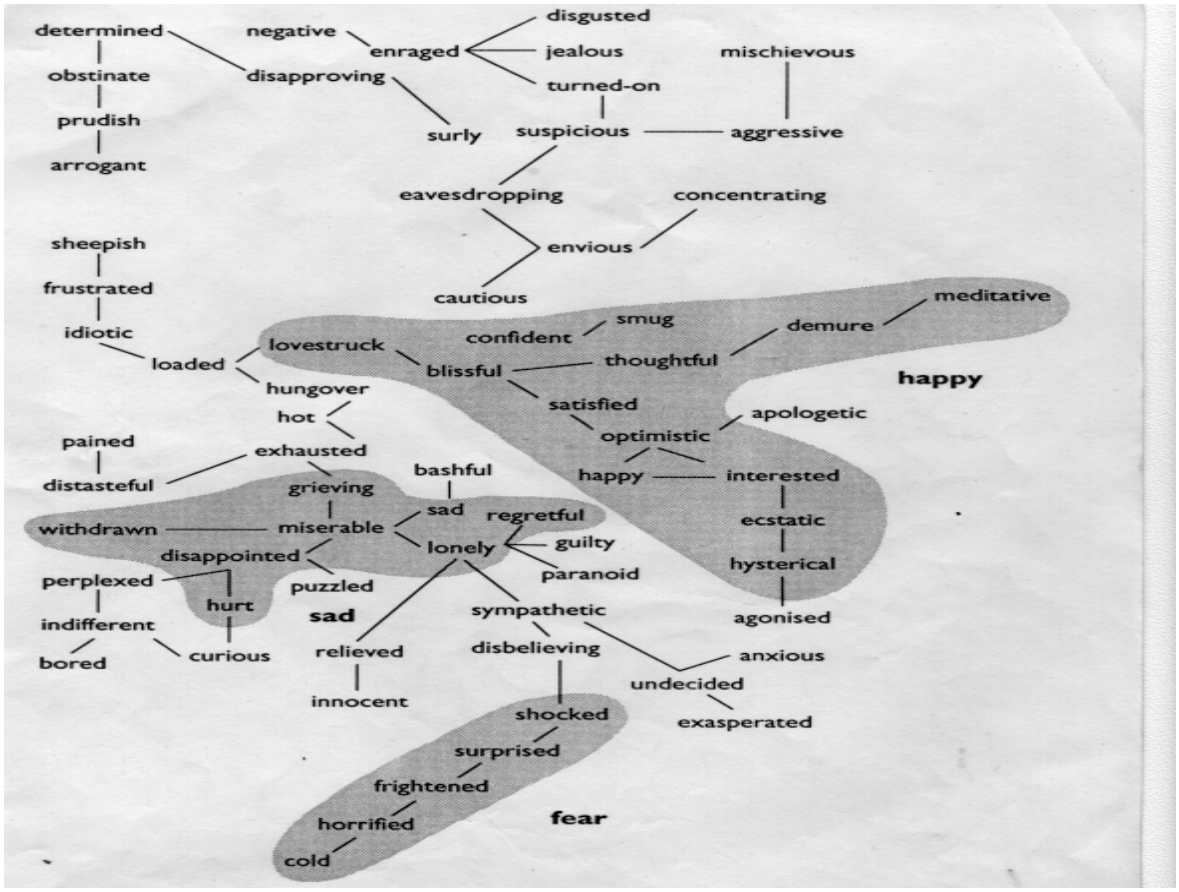

Figure 3: Pathfinder analysis showing 42 British subjects' strongest associations among emotion icons

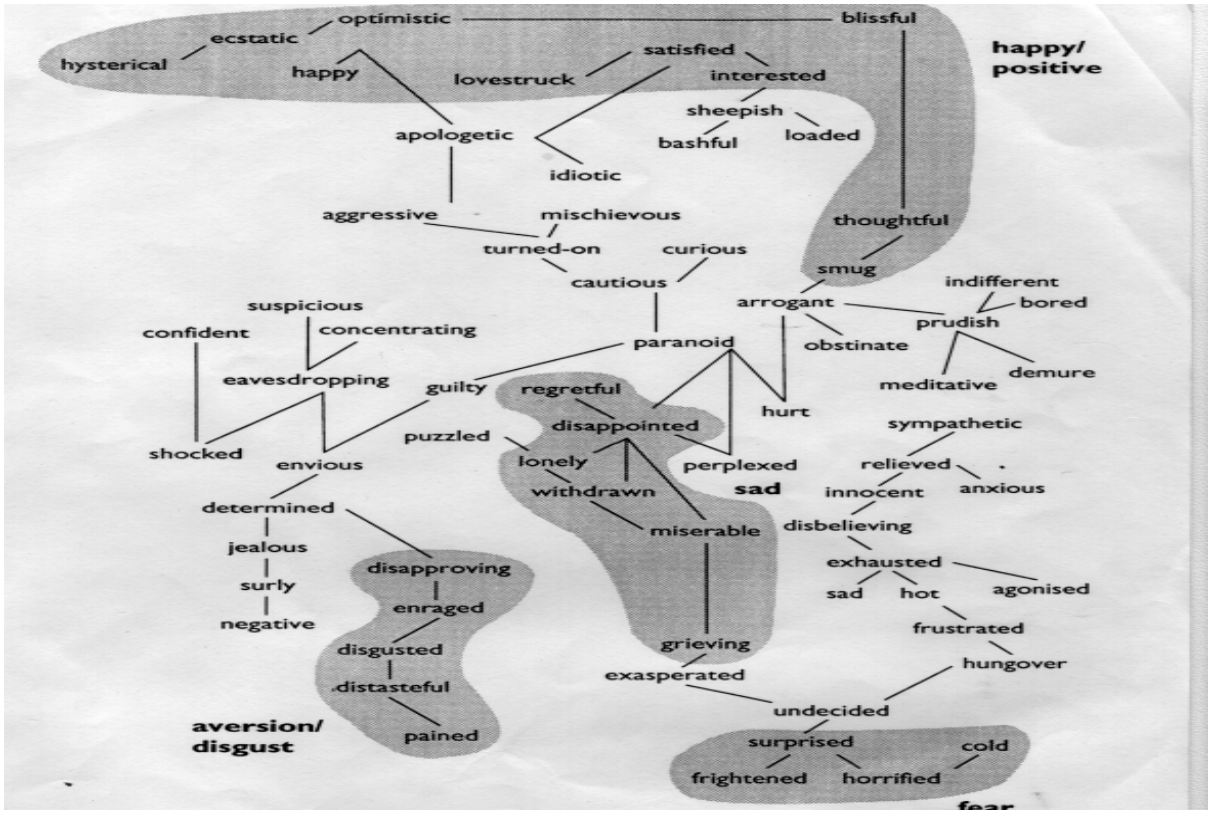

Figure 4: Pathfinder analysis showing 60 Chinese subjects' strongest associations among emotion icons

Superimposed on the Pathfinder network are clusters showing some of the major theoretical groupings in emotion categories. These clusters can be derived directly from the weightings associated with each link by considering the association strengths between pairs, and "breaking" the linkage structure at the boundaries of the most weakly associated pairs. Cluster analysis provides a view of the data at a slightly higher level of abstraction than the raw linkages, and in this case the mathematically derived clusters comport well with those expected from theory, with examples of the major emotion categories indicated. In determining the boundaries for the present diagrams, the mathematical distances involved were considered in conjunction with the semantic categories predicted by theory, and the high cross-cultural agreement for the major categories of sadness, fear, and happiness is evident.

The diagram implicitly indicates a third level of abstraction, that of the primary dimensions of a multidimensional scaling analysis (MDS). MDS provides a complementary view of the data to Pathfinder, and the network layout program[3] seeks to display the items projected onto a plane indicating the major dimensions, or global differences in the data set. Without emphasising this analysis, it seems evident that the Chinese subjects place the primary euphoric and dysphoric emotions at opposite extremes, whereas this pattern is less clear in the British subjects, whose primary distinction may be better described as between passive (inwardly) and active (outwardly) directed emotions. This observation however, will not be pursued here. The standard finding in studies such as this is that there is typically a "pleasant" cluster and an "unpleasant" cluster, often negatively correlated (Frijda, 1987), and two contrasting basic emotions seems both more elegant and reliably demonstrable than five or more. While showing such a distinction may be of little theoretical interest to researchers in emotion, one difference with the present study is that, deprived of verbal descriptors, subjects nonetheless could reliably classify expressions characteristic of the major emotion categories. Both cultures tended to group the "happiness" expressions together. This is an expression known to be recognised more quickly and accurately than any other (Kirita and Endo, 1993) and has proved easiest to distinguish in a computer based classification using distances between facial landmarks on digitised images (Katsiktis and Pilowsky, 1993).

From these diagrams it is clear that while some general similarities exist, there are also numerous detailed differences, and whilst an analysis of the proportional overlap of pairwise links common to both diagrams, or an item reliability analysis could be done, this particular stimulus set is not of primary interest. Instead, our main purpose has been to establish whether context-free icons representing distinctive emotional states can, in general, be reliably perceived across different cultures. Having established that in principle emotional expressions can be reliably conveyed in this way, we plan to go on to use this methodology in specific studies of more directly applied interest. Our general discussion now indicates some implications from this study.

3. Discussion and conclusions

Our study has shown that it is essentially possible, without other contextual information, to coherently categorise the affective state betrayed by facial expressions. This pattern has held true across distinct cultures, backing up previous work (see Ekman, 1993). Although this particular stimulus set requires further validation for representativeness and reliability prior to utilisation, as a set of simply drawn, anonymous faces the stimuli demonstrate several characteristics generalisable to specific picture-coded application areas.

The effect of race is minimised: the underspecificity compared to photographic representations implies that an essential, and non culture-specific characteristic is being captured: the caricature emphasises the important aspect of affective state. In specific task-oriented teams, working

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[3] The KNOT analysis tool for Pathfinder performs this function, and is available from Interlink Interlink, Inc. P.O. Box 4086 UPB Las Cruces, NM 88003 at http://internet.roadrunner.com:80/~interlink/knot.html

collaboratively but remotely, fine tuning on such a stimulus set for the individuals involved would allow both a context and a record for the feelings associated with (for example) decisions made, addressing the well-noted problems of intercultural misunderstandings.

The stimulus set can be replaced with representations of particular individuals in a work-team, with central representatives of a class, or with other iconic material, and the methodology allows consistency of interpretation to be established, along with areas of dispute or misunderstanding. Using computer generated images differing by constant physical amounts, Etcoff (1993) has shown that, like colours, emotional expressions are perceived categorically, rather than as a direct reflection of their continuous physical properties. As a first approximation, given the universal perceptual dominance of happy expressions, conveying a graphical or digitised representation of these can be used to indicate satisfaction during a remote group decision making process.

From this initial basic research there are several directions for further work that we plan to explore, based on this methodology and tailored to specific application areas. Building on the earlier observation that the informal (and often unrecorded) communications within collaborative working situations often determine the real outcomes we aim to introduce the language of affect into collaborative decision making showing a record of the development of satisfaction or otherwise with some outcome. Our hypothesis is that in collaborative design decisions in particular, modelling this alongside formal, verbal records may help detect critical areas of design decision, and will enhance the interpretive context of a stated position.

A second line of work concerns future human computer interfaces, and conferring intelligence upon these. In this line of work the issues concern tailoring the machine response mediated through the interface to the characteristics of the user. (Norcio and Stanley, 1989). One such interesting issue for intelligent interface design concerns using AI techniques within the computer itself, to use perceived facial expression as a factor in building a user model. Already there is experimentation going on in thought controlled interfaces, where the computer detects the electrical changes in the user's brain associated with particular choices, and responds to those before they come to conscious awareness. Such an approach may have utility in extremely critical real time systems, and may take advantage of the delay between formulating a thought, and its manifestation in consciousness. However, without a semantic model interpreting such electrical changes may be problematic.

In interfaces with built-in intelligence, it is critical that the representation of affect map on to a model of the user that preserves human semantics (McKevitt and Gammack, 1996). This can be seen by analogy with findings in AI, where statistically successful classifications can be shown, but which are not communicable beyond the classification algorithm. For instance in the soybean disease classifier of Michalski and Chilauski (1980) a set of criteria established by machine induction techniques performed well in classifying a sample set correctly, but which could not be expressed in humanly meaningful rules. Similarly, speech recognisers may be able to perform successfully at a functional level, but without any notion corresponding to the humanly meaningful phoneme. In traditional cockpit design the instrument interface has made use of similar properties, replacing numbers (a derivative representation) with visual analogue indicators wherever possible. Although increasingly numeric data is presented on monitors and processed electronically, such instruments tend to be preferred by pilots for their relative ease of use. As pictorial representations naturally convey complex information more immediately, we suggest that for interfaces which convey information originating and processed in the human or social domain, the representational constructs used in design preserve those of human psychology. In the face recognition work of Brunelli and Poggio it is notable that the classifiers are mathematical refinements of humanly meaningful categories. The Pathfinder technique used in this study has been applied in this area of interface design (McDonald and Schvaneveldt, 1987), and intelligently processed information on affective state will surely become a part of the generalised adaptation of interfaces to future systems. Recent work in the cognitive psychology of face recognition has cast doubt on the modularity thesis (Rhodes and Tremewan, 1993) and in the light of our earlier remarks on a culture's psychosemantic context, we consider it important that any face recognition module be integrated within a more general semantic process.

A related ergonomic issue concerns the computer recognition of Chinese characters, which will become critical as pen-based interfaces become more prevalent. Pen computing is seen as a key solution to the problems with keyboard input of Chinese characters. The technologies of feature recognition in faces are in principle similar to those of feature recognition in handwritten characters. Psychological methods for classifying the human categories upon which discriminations are made (Gammack, 1990) can be expected to supplement the mathematical techniques of global and structural physical feature extraction (Hsieh and Lee, 1991).

Finally, we hope to enhance our understanding of one another and our diverse cultures through research work and communication based on our deeper similarities.

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