

# **Emotion in HCI – Designing for People**

Proceedings of the  
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# Emotion in HCI – Designing for People

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## ABSTRACT

As computing is changing and becoming increasingly social in nature, the role of emotions in computing has become ever more relevant and commercial. Emotion are central to culture, creativity, and interaction. The topic attracts more and more researchers from a range of multidisciplinary fields including design, gaming, sensor technologies, psychology and sociology. The need for discussion, exchange of ideas, and interdisciplinary collaboration is ever-increasing as the community grows. This workshop will meet requirements of individuals working in the field, giving them a podium to explore different aspects of emotion in HCI, raise questions and network with like-minded people on common subjects. The workshop will focus around working group sessions, and will use predominantly small group work, rather than being presentation-based.

## Categories and Subject Descriptors

C.5 Computer System Implementation, D.2 Software Engineering, H1.2 User/Machine Systems, H5.m. Information interfaces and presentation

## General Terms

Algorithms, Management, Measurement, Performance, Design, Economics, Reliability, Experimentation, Human Factors, Languages, Theory, Legal Aspects, Verification.

## Keywords

Emotions, Affective Computing, Design, Applications, Sensing, Theories, Human-Computer Interaction, Emotion Recognition

## 1. INTRODUCTION

Emotion influences both human-human and human-computer interactions in most of our daily experiences. They affect our physiology, facial and bodily expressions, decision making, and social interactions, and are what make our interactions human. Rosalind Picard was one of the first to document the importance of emotions in human-computer interactions in her fundamental publications on affective computing [1][2][3]. Since then, research in this field has gained significant momentum as researchers have worked to understand the subtleties of emotion and its effect on our behaviours. The important role of affect and emotion for design and in interaction, be it with humans or technology, is meanwhile recognized and accepted within the HCI community. We witnessed a very active affective computing community at previous workshops, with many new publications and related events addressing affect and emotion in HCI [5][6][7][8][9].

With this workshop, advancement in the field will be promoted by providing a space for interested researchers to explore common ground, share current work and developments, and discuss obstacles faced. A primary challenge for the study of emotion within HCI is the interdisciplinary nature of this research, so we expect the workshop will attract individuals from a wide range of backgrounds. In previous workshops we discussed a range of topics from understanding emotions' function in HCI to the practical implications and consequences of emotion for the HCI community. The workshop at HCI 2008 will serve as a good forum to take discussions on to the next level and to explore new developments.

The previous three BCS workshops on 'emotion in HCI' [10] [11] proved to be a good meeting place for like-minded people investigating aspects of emotion in the wide field of HCI. As such, they had a wide basis and participants worked collaboratively on selected topics, with increasingly tangible results [10]. Building on previous successes, this year's workshop aims at bringing the community further together and continuing the consolidation process.

With this year's conference having the theme "Culture, Creativity, Interaction", we would like to encourage contributions which take particular account on cultural aspects in HCI related emotion research, and on effects of affect and emotion on creativity. Hence, the following list of specific and more general topics is non-exclusive:

- How do emotions relate to culture, creativity and interaction?
- How do emotions relate to hot topics in HCI such as engagement, motivation, and well-being?
- Are there reliable and replicable processes to include emotion in HCI design projects?
- Which ethical issues arise and how to address these?
- How do applications currently make use of emotions?
- What makes applications that support affective interactions successful, how do we know, and how can we measure this success?
- What value might affective applications, affective systems, and affective interaction have?
- What technology is currently available for sensing affective states, and how reliable are they?

As with previous workshops, which resulted in a Springer book publication [12], this interactive and focused workshop is designed to produce tangible and citable outcomes.

## 2. WORKSHOP PROCEDURE

We will solicit submission of position papers (ca. 800 words) related to the subject. Case study papers describing current applications or prototypes are strongly encouraged. In addition to conference specific themes (cultural aspects, creativity), we would also welcome more general contributions and demonstrations.

As a way of bringing the domain to life, presentations of products or prototypes that participants have been involved in are highly encouraged.

The call for papers will be submitted to relevant newsgroups and mailing lists, within relevant European Networks of Excellence such as [emotion-research.net](http://emotion-research.net), and published on the workshop's website [13]. Papers will be reviewed by the workshop's organizing team.

Position papers and short biographies will be circulated amongst all accepted participants before the workshop..

The format of the workshop is designed to encourage interaction between participants. The workshop will be divided into:

1. Brief introductions. Each participants will be invited to talk up to 3 minutes to introduce themselves and their research;
2. Working Groups. Four thematic sessions allowing the participants to work collectively, in small self-chosen groups, on selected themes. The general topics for the sessions will be prepared in advance, with the option to select more specific topics depending on the group members' interests. Working groups are expected to produce tangible results.
3. Create outputs. A concluding part to consolidate findings. We will spend considerable time on this to ensure that tangible outputs are generated.

The focus of the workshop is on discussions and group work on selected themes. After each thematic session participants will join a new group for the next session. This will allow participants to work with many people and on more than one subject over the day, a format that was very well received in last year's workshop. The anticipated outline is as follows:

**Introduction:** The organizers will introduce themselves and review the goals and format of the workshop. A brief game related to the topic of emotions will act as an ice-breaker. Each participant is invited to talk for about 3 minutes about themselves and their research interests.

**Initial group forming:** A brief session during which topics of interest and key concepts are reviewed and discussed. The purpose of this short session is to set the foundation for the thematic sessions, identify specific areas of interest and form the first set of working groups.

### Working groups 1

Two groups will form to work on one selected topic each. Their group work will comprise

- defining the starting point of discussion (foundations, general assumptions);
- identifying open issues with regard to affect or emotion;
- developing solutions for issues identified;
- working out evaluation criteria;
- summarizing their work.

At the end of this session, each group will report on their work and discuss the outcomes of their effort with all participants.

**Demos:** A 30-minute slot for demonstrations of working prototypes of affective applications, sensors, data analysis tool and other related work.

### Working groups 2

Similar to working groups 1 participants will form two groups to work on new subjects. Procedure will be the same as in the first working group session.

**Create outputs:** By collating and debating the findings of all working groups, we will aim to develop tangible deliverables such as joint publications on issues identified in the workshop, collaboration efforts, networking activities or grant proposals.

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# Dispositional Expressivity and HCI

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## ABSTRACT

Spontaneous emotional behaviour in Human-Computer Interaction (HCI) reveals significant individual variability in expressiveness. This is in concordance with nonverbal behaviour research that indicates differences in the manner and intensity by which people express their felt emotions. To explore the implications of this individual personal style for affect modelling and recognition, we seek to compare some standard self-report expressivity measures with global indicators of nonverbal behaviour in a standard HCI task. Our objective is to see how well these psychometric tests predict expressivity in HCI and whether global indicators of observed quantity and quality of motion are a feasible measure.

## 1. INTRODUCTION

Observations and analysis of spontaneous emotional behaviour revealed significant variability in expressiveness of our subjects. This individual variability was quite apparent given that the subjects were of comparable age and similar ethnicity, and were doing identical tasks. Though our sample size is not enough to generalise this observation across HCI settings, nonverbal behaviour research shows that there are indeed differences in the manner and intensity by which people express their felt emotions. Furthermore, Riggio and Riggio [1] highlight that emotional expressiveness as a personal style is relatively consistent across situations. As such, it should be interesting to observe if and how this dispositional expressiveness translates to HCI settings and what implications this could have for HCI in general and affective computing applications in particular. Our objective is to examine how well the standard measures of nonverbal expressivity predict expressivity in HCI, how we can measure expressivity in HCI, and eventually, what implications this could have on affect modelling and recognition.

## 2. EXPRESSIVITY AND ITS MEASURES

The construct of emotional expressivity is defined in two ways: to denote skill in sending messages nonverbally and facially - also known as nonverbal encoding ability [2], and as a general expressive style, a central component of individual personality [3]. Behavioural assessments and self-report measures are the two ways of measuring nonverbal expressiveness. Lack of standardised observation tests together with cost, time and reliability issues have made researchers turn to self-report means of assessing nonverbal or emotional expressiveness and have had good success with these [4].

Self-report measures of nonverbal expressiveness assess individual differences in the generation and/or expressions of emotions and a more general tendency to display affect spontaneously and across a wide range of situations. The popular measures include: Perceived Encoding Ability (PEA), Affective Communication Test (ACT), Berkeley Expressivity Questionnaire (BEQ), Emotional Expressivity Scale (EES), Emotional Expressivity Questionnaire (EEQ), Social Skills Inventory-Emotional Expressivity Sub-Scale (SSI-EE), Test of Attentional & Interpersonal Style (TAIS), Affect Intensity Measure (AIM) and Emotional Intensity Scale (EIS).

Based on how the construct of emotion is conceptualised, which component of emotion is assessed, the target population and administration time, availability, and psychometric properties like reliability and internal consistency, we selected three self-report tests for measuring individual expressivity. These are:

1. Affective Communication Test - ACT [3]. This is a 13-item measure of dynamic expressive style and assesses individual differences in the ability to transmit emotions. It is strongly related to personality traits.
2. Berkeley Expressivity Questionnaire - BEQ [5]. This is 16-item instrument that conceptualises expressivity as the behavioural changes associated with the experience of emotions. It emphasises observable behavioural reactions.
3. Emotional Expressivity Scale - EES [6]. This is a 17-item scale that conceptualises expressivity as a stable, individual-difference variable and captures the general construct of expressivity. It is presumed that expression is consistent across situations and across communication channels.

## 3. MEASURING EXPRESSIVITY IN HCI

In absence of a standard measure, we are using a somewhat eclectic approach to measure the overall expressivity in an interaction sequence by using six global dimensions of expressivity, the number of emotions perceived, and the occurrence of specific facial action units and head gestures. The idea is to see if there are any global indicators in terms of quantity and quality of movements and gestures that can give an overall estimate of expressivity.

Based on a global level speech annotation method in Martin et al. [7] we consider the following six dimensions of expressivity:

1. Overall activation: amount of activity - {Static/Passive, Neutral, Animated/Engaged}.
2. Spatial extent: amplitude of movements - {Contracted, Normal, Expanded}
3. Temporal extent: duration of movements - {Slow/Sustained, Normal, Quick/Fast}
4. Fluidity: continuity and smoothness of movement - {Smooth, Normal, Jerky}
5. Power: strength and dynamics of movements - {Weak/Relaxed, Normal, Strong/Tense}
6. Repetitivity: repetition of same expression/gesture several times - {Low, Normal, High}

We are also recording the occurrence of facial actions and head gestures in the interaction in order to get a quantifiable estimate. Summary statistics and properties of these facial action units may give a measure of individual motion bias which has been found to influence between-class variability of certain affect states [8]. This is important for automatic classification of affect states.

In addition, we are recording the number of affect states or emotional episodes that are attributable to an interaction sequence. This will enable us to know if one can perceive emotions from behaviour irrespective of observable changes in nonverbal behaviour. This is vital for affect inference studies that depend on mapping affect states to observable movements.

#### 4. METHOD

We are running this study along with a data collection exercise in which subjects are videotaped while doing an online tutorial. The subjects are asked to complete the three self-report measures after completing the computer-based task. In an attempt to get naturalistic behavioural data, subjects are not made aware of the purpose of the experiment before finishing the task. This is followed up with the global level annotation of collected videos along the parameters defined in Section 3.

#### 5. CONCLUSIONS

Considering that there is a whole body of research on individual or dispositional expressivity, it is rather ironic that it remains a rather unexplored area in affective computing - a field that seeks to analyse and model affect phenomenon. Current practices in affective computing are oriented towards developing generalised techniques for affect detection and modelling. While there are instances of using personality profiles in user models [9] and an interest in personal motion bias [8], the concept of individual nonverbal expressivity has not yet been studied quantitatively nor has its potential in detecting affect correlates looked into. As we

move towards naturalistic data analysis, the factor of individual variability in expressiveness will become too apparent to be ignored. It is possible that we might need to think beyond general abstraction and think of more personalisation in our methods and practices – like in speech recognition where a canonical model adapts to individual verbal styles. Automatically measuring dispositional expressivity will be a challenging step.

#### 6. ACKNOWLEDGMENTS

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# The development of a graphical emotion measurement instrument using caricatured expressions: the LEMtool

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## ABSTRACT

This paper outlines the early stages of development of a visual measurement instrument specifically designed to measure emotions in digital media, with the focal point being websites. For this reason, eight emotion terms most relevant to digital media were selected and visualized by an expressive cartoon figure using theories of facial caricaturing. An early prototype of the instrument will be presented in conclusion.

## Keywords

Body language, caricature, digital media, emotion, facial expression, LEMtool

## 1. INTRODUCTION

Digital media, and most profoundly the Internet, play an increasingly central role in human life. Mediated communication in the form of e-mail and personal expression through blogs illustrate ways in which emotions are introduced on the web. With regard to research on emotions, the Internet is a particularly challenging area because of its highly interactive characteristics. Consider websites for instance; when one encounters a website that provokes disgust as a result of an unpleasant visual design, all a user has to do is hit the back button in the browser to withdraw from the emotionally unpleasant interaction. Furthermore, humans have an extraordinary ability to make very rapid judgments of visual qualities of a website [17]. The influence this can have on the experience of emotions is similar to emotions elicited by 'real-life' stimuli [5, 22].

This underlines the need to be able to understand and measure emotions in digital media. Employing measurement techniques specifically designed for use in digital contexts is paramount in this regard. The following section will describe the development of such an instrument, the LEMtool (Layered Emotion Measurement tool).

## 2. DEVELOPMENT

The underlying principle of the LEMtool is the innate ability of humans to recognize expressions of emotions in other humans through facial [7, 9, 11, 27] and bodily [1, 13, 28] cues. The strength of this approach lies in the fact that semantic knowledge that is of influence on the report of emotions [18, 24] is eliminated completely. Additionally, innately recognizable expressions make cross cultural application more feasible [7, 8, 9].

The LEMtool has been developed to depict emotions in the most clearly recognizable way. In order to achieve this a cartoon character has been developed that shows caricatured expressions of emotions. Facial caricaturing (i.e. reduction of facial information redundant to the expression and exaggeration of the essential components) has been found to enhance the recognizability of emotions [3, 4, 15].

Some instruments aimed at measuring emotions through facial caricaturing already exist [2, 6] but none of these are specifically geared towards highly interactive digital media. For this reason several emotion terms most relevant to Human-Media-Interaction were selected [12, 14, 16, 19, 21]. Table 1 lists the selected terms as well as the areas of digital media they relate to.

Table 1. Selection of HMI relevant emotion terms

| Positive emotion | Negative emotion | Category                 |
|------------------|------------------|--------------------------|
| Joy              | Sadness          | Likability               |
| Desire           | Disgust          | Aesthetics               |
| Fascination      | Boredom          | Aesthetics/<br>Usability |
| Satisfaction     | Dissatisfaction  | Usability                |

On the basis of these emotion terms eight images of a cartoon figure expressing the emotions were created by a professional cartoonist. Theories on the expression of emotions through facial expression [10, 26] and body language [28] were used to help create a cartoon figure that was sensitive to underlying dimensions of emotional expression. The recognizability of the expressed emotions will however have to be assessed through future validation studies.

## 3. APPLICATION

Application of the LEMtool is founded on the notion that emotions can happen rapidly [8, 12, 25], especially in interactive mediated contexts like the web, where rapid changes in eliciting stimuli (e.g. webpages) are expected as a result of the high level



**Figure 1. Steps in the use of the LEMtool.** Figure 1a shows the emotion token in the top right corner. In figure 1b the emotion token is dragged to an emotion eliciting element of a website. Upon release of the token the user can rate the emotion experienced by selecting and rating the cartoon figure expressing an emotion (figure 1c). Please note that the cartoon character used here is not representative of the final character.

of interactivity of the medium. So if one is to obtain accurate measurements of experienced emotions, measurements have to be taken instantly and intuitively [20, 23]. This means deployment of the actual instrument will have to happen during the interaction with a website. The naming of the LEMtool implies how this is done, namely by applying a 'measurement layer' over any

website. This layer can be activated by the user when an emotion is experienced to indicate his or her emotional experience at that time and place on the website.

Depending on the experimental set-up the measurement layer can be activated at set intervals in order to obtain data at specific points in time during an interaction with websites. For instance activation of the layer early in the interaction (e.g. two seconds) will provide information on the emotional experience of the aesthetics of the website because aesthetic qualities are assessed very early during web-interaction [17].

The actual layer itself consists of the emotions expressed by the cartoon character organized in a circular structure. Users can select one or more emotions and rate their intensity on a three point scale. Figure 1 depicts how the LEMtool measurement layer might work during an interaction with a website.

Future development will consist foremost of refinement and validation of the expressions of the cartoon character used in the instrument. Usability of the instrument also remains an area where further study is needed.

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# Using induction and multimodal assessment to understand the role of emotion in musical performance

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## ABSTRACT

This paper presents studies of emotional behaviour during a music performance. Two experiments aimed at investigating which gestural, acoustic, and physiological cues characterize musicians' emotional processes. Emotional expression was created by verbal instruction, by a relaxed emotion task, and by a more powerful induction procedure (MIP) based on Velten technique. The paper focuses on the design and instrumentation issues. We address the definition of the necessary motoric and physiological data, the methodology of emotion induction procedure and the problem of minimizing intrusiveness in an ecologically valid environment.

## Keywords

Mood induction procedure, multimodal cues, emotional process, data synchronization, music performance.

## 1. INTRODUCTION

Technology is deeply involved with music, for multiple reasons. There are massive industries involved in recording, packaging and distributing music. Contemporary musicians use an extraordinary range of technologies to produce sounds. 'Sonification' stands on the borderline between art and understanding of phenomena from DNA to EEG. Automatic generation of music is becoming a serious undertaking. Accessing music is a difficult and commercially important problem for search technologies. The list goes on.

All these activities, though, take their significance from experiences that are notoriously elusive – the intensely subjective experiences of the performer who generates music, and the listeners who respond to it. This paper reports research that aims to engage with those experiences, and specifically with the experiences of the performer.

Clearly emotion is a central feature of musical experience. Musicians aim to express emotion in their performances, and if they succeed, it induces emotion in their audience. This study chose emotion as an avenue into the study of the intensely subjective experiences that link performers and listeners. One of the key reasons is that emotion is associated with a multitude of signs that can be recorded objectively.

Emotion is a multimodal phenomenon. Nobody doubts that subjective feeling is central to it. It has also been recognized for over a century that it is closely bound up with bodily changes – in heart rate, breathing, skin conductance, temperature, muscle tension, and so on [1]. A second range of components relate to motor activation and action [2]. The body is also an important channel to communicate affect, and people naturally express emotions through the use of their motor skills [3][4]. Interest in the role of these 'expressive gestures' is developing [5].

This paper takes up a question that may have the potential to illuminate some of the difficult issues surrounding the subjective experience of emotion and its role in music. It is whether performance designed to evoke an emotion is truly like performance that flows from true emotion. At one extreme it may be the case that musical performances evoke emotion in audiences by transmitting an underlying emotion that is genuinely felt by the performer. At the other extreme, it may be that the performer simply produces appropriate signals, and the audience responds whatever lies behind them. Science being what it is, we would expect the truth to lie between the extremes; but without research, it is not obvious what kind of intermediate position might make sense.

To study these issues, we have obtained a rich body of data from expert musicians taking part in the Paganini International Violin Competition. This paper presents an overview of the project, and particularly the technical innovations, including induction techniques and design of technology infrastructure. An archive of synchronized multimodal data has been recorded and is currently being analyzed. We describe key features of the data. These cannot be conclusive given the small sample size, but they indicate that the approach is promising.

## 2. THE EXPERIMENTAL SET UP AND THE MULTIMODAL ARCHIVE

Three kinds of input devices were used: to build a high quality archive of synchronized multimodal data.

1) Video cameras To capture gestures of the violin performers, we used two standard video cameras and two ultra-fast full-frame shutter digital cameras (the Silicon Imaging SI-1280F- one B&W and one RGB, at 1280 \* 800, 45 fps). To

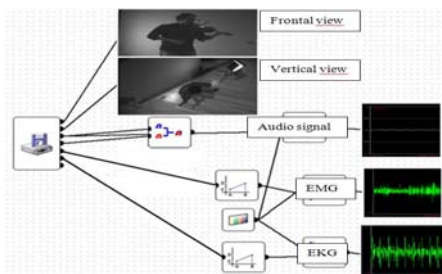
capture both full-body gestures and arms/hand/fingers gestures, two (25fps) were 5 metres vertically above each performer, and two (45fps) in front.

2) Microphones Two Neumann KM 184 cardioids microphones and two radio microphones (AKG C444) were used to record environmental sound and near-violin sound respectively (at 48 kHz and 16 bits per channel).

3) Physiological sensors Signals were recorded using Infusion Systems sensors ([www.infusionsystems.com](http://www.infusionsystems.com)), being able to record electrocardiogram (ECG), galvanic skin response (GSR) from the right hand, electromyogram (EMG) from the right forearm, left forearm, and left calf, and one electroencephalogram (EEG) channel from the violinist's forehead. Furthermore, a tri-axial accelerometer was mounted on the violinist's back, and two force sensing resistors (FSR) were placed on the left shoe, in order to capture movement and front to back balance.

All of the above techniques were designed to minimize interference with the performance of the piece. The shoe sensors were placed underneath the shoes they wore for the performance. All of the physiological sensors were composed of dry electrodes (no electrolyte or site preparation needed) placed inside elastic bands. The violinists were then asked if they felt they had any effect on their performance. The answer with both subjects was no.

Data were synchronized and recorded in real-time through the EyesWeb XMI open software platform.



**Figure. 5. An EyesWeb XMI application we implemented to display synchronized multimodal data of the music performance**

## 3. METHOD

### 3.1 Emotion induction

The studies used two methods of influencing emotional expression. With verbal instruction, musicians were asked to play so as to convey a desired emotional state. With induction, a psychologist induced the relevant emotional state using a relaxed emotion task [7]. The technique was chosen because its effects persist. It combines two standard elements, the Velten procedure and an autobiographical memory technique [8].

The full form of the induction technique, described below, was used in the second study. The first study used an abbreviated version, which the evidence suggests did not induce robust effects.

For elation, the full technique used involved three distinct stages: At stage 1, participants were asked by the experimenter to take approx 10mins to think about, and list at least 5 different topics for conversation at phase 3. Participants were asked to list things in their lives that made them experience joy or elation, specifically “joyful and happy (more specifically, feeling positive, bright and full of activity)”. In order to get help participants get started, they were presented with a short list of some popular ‘elation topics’. Participants were allowed to select as many of these topics as they wished, but were encouraged to include at least two of their own on the list.

Stage 2 was a standard mood induction technique, the Velten MIP-E, administered in the standard way.

At Stage 3, the experimenter engaged the participant in a short (5-7mins) discussion of one or more of the topics chosen at phase 1. The participant was allowed to choose the starting topic from the list and the experimenter encouraged him/her by being empathic, energized and animated, and as enthusiastic as was appropriate and believable.

For sadness, the technique involved the same three stages: Stage 1 was the same as before, except that participants were asked to list topics that made them sad and depressed, specifically “feeling something is deeply distressing, but all you can do is find a way to reconcile yourself to it”.

Stage 2 was a Velten procedure administered in the standard way.

At Stage 3, the experimenter again engaged the participant in a short (5-7mins) discussion of one or more of the topics chosen at phase 1. During this stage of the sadness induction, the participant's state was monitored very closely by the experimenter. It was important that the participants felt comfortable enough to talk about issues that made him/her feel sad, but the aim was not to upset participants unnecessarily. The procedure lasted approx 45mins.

### 3.2 Emotion measures

**Dimensional Measure:** As in the previous experiment, participants used Lang's Self Assessment Manikin (SAM) (Lang, 1980) to describe their emotional state in terms of 3 dimensions: pleasure, arousal, and dominance.

**Categorical Measure:** Participants selected up to three labels from the same list of affective descriptors (Douglas-Cowie, et al., 2003) as was used in the previous experiment.

### 3.3 Performance

Participants were professional violinists. The stimulus material was selected music scores by J.S Bach: A unison canon extracted from the Musical Offering, the Partita for solo violin no. 3, Prelude and the Violin Sonata in G minor. These pieces are not marked for expression, so that the musical interpretation could be considered as resulting from the musician's choice or induced state.

In experiment 1, each musician performed the canon four times, to convey anger, sad, joy, and peaceful. These cover the basic combinations of the major affective dimensions, arousal and valence [6](see Table 1).

**Table 1. the emotions in the space valence-arousal**

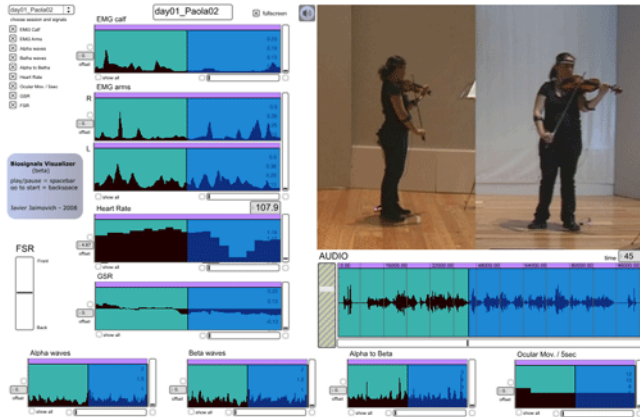
|                     | Positive valence | Negative valence |
|---------------------|------------------|------------------|
| <b>High-arousal</b> | Elation          | Anger            |
| <b>Low-arousal</b>  | Peaceful         | Sadness          |

In experiment 2, the full induction technique was used to induce each participant into the emotional states of sadness and elation. They then played three Bach music scores.

To evaluate effectiveness, self-reported mood ratings were collected using the Self Assessment Manikin [11] plus an Affective Labels list [12].

## 4. RESULTS

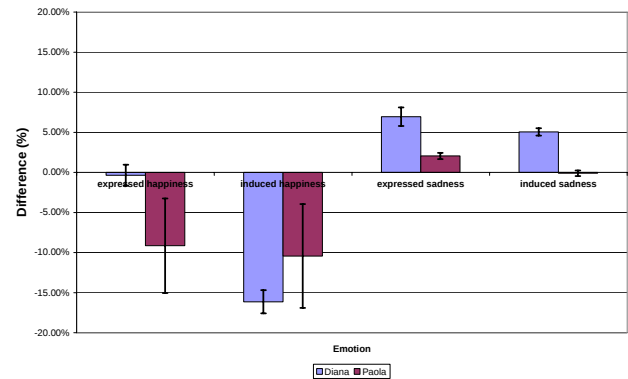
The acquired data was analyzed using statistical analysis and the use of a Max/MSP developed specifically for this analysis, which allows to browse and visualize all the recorded signals simultaneously and in real-time.



**Figure 2. Screenshot of the Max/MSP real-time visualization patch.**

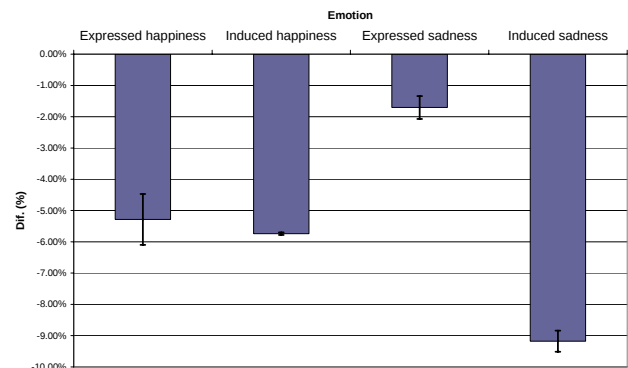
Analysis on the duration time of the performance for the three pieces played showed significant changes between the expressed and induced emotions when compared to the neutral state. During induced happiness, both musicians increased the tempo of the performance (up to 18% in some cases). This was faster than when they were asked to play expressing elation. On the other hand, the performances where they were asked to play expressing sadness resulted in a slower tempo than the ones after the sadness induction procedure.

**Performance duration time related to neutral state**



**Figure 3. Changes in the duration of the performance time for both musicians under different emotional states.**

**Diana's Average HR compared with Neutral State**

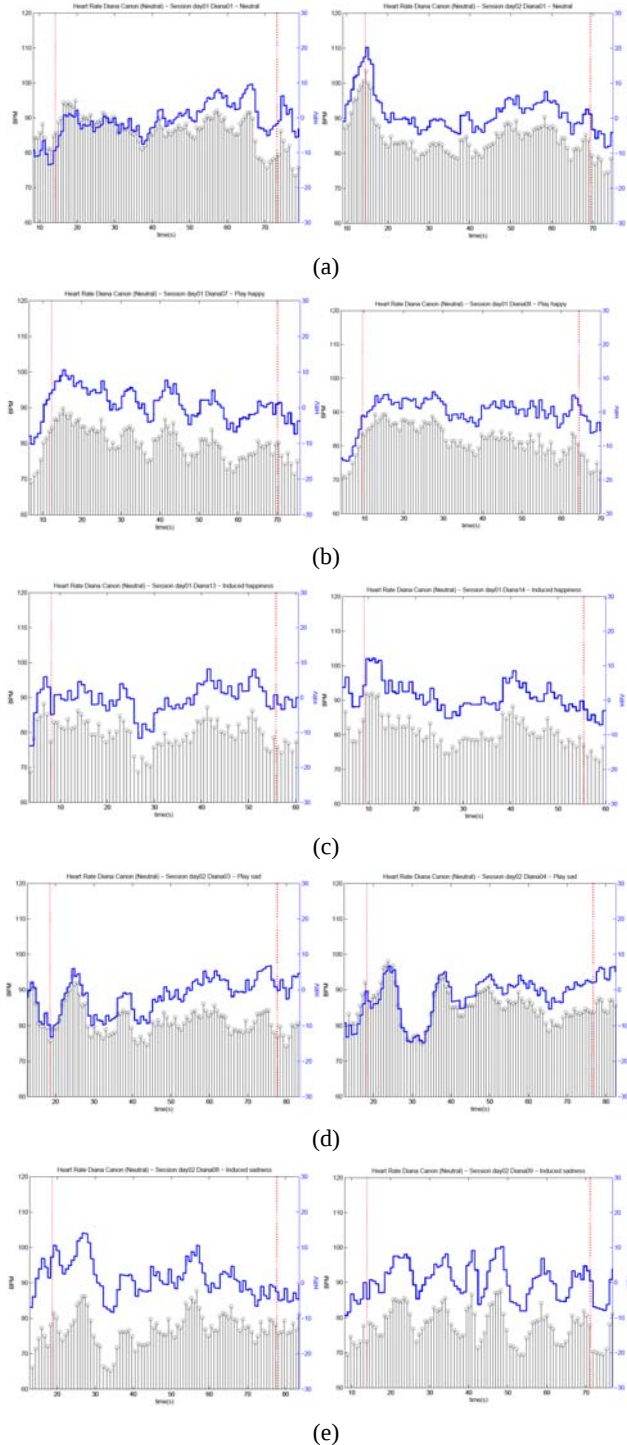


**Figure 4. Relationship of average HR during performance compared the neutral state average HR.**

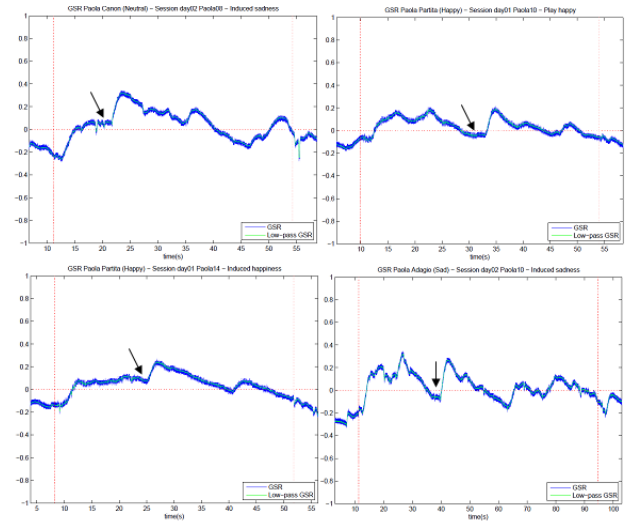
The average HR during performance showed an average decrease of 5.5% for expressed and induced happiness, while the HR for induced sadness was almost 10% lower than neutral, and interestingly dissimilar with expressed sadness. If we examine the average HR with the performance's duration time, there is no suggestion of a relationship between tempo and HR, which could be suggested by the increase or decrease of physical activity with a higher or lower tempo.

Heart rate variability was examined throughout the duration of the performance, as can be seen in figure 5 (vertical dotted lines mark the start and end of the musical piece). A relationship between the HR with the musical score was found in several recordings, where specific musical figures had a correlation with the variations in heart rate.

A similar pattern in HRV for recordings of the same emotional state can be identified in specific musical phrases, as well as the overall variability, which also seems to correlate between recordings of the same conditions.



**Figure 5.** HR and HRV during the performance of the same musical piece in different emotional states. (a) Neutral (b) Expressed happiness (c) Induced happiness (d) Expressed sadness (e) Induced sadness.



**Figure 6.** Changes in GSR associated to mistakes in musical interpretation (top left, top right and bottom left) or difficult sections in score (bottom right).

Both HR and galvanic skin response manifested an increase in their level before the start of the performance for the majority of the recordings. No correlation between GSR and the emotional state was suggested by the results. Significant changes in GSR level were often related to interpretative mistakes made by the performer, or associated to difficult sections of the score (figure 6).

EMG analysis returned an increase of 15% in the right arm tension for one of the violinists after the induced sadness procedure, while the other musician presented an increment in both expressed and induced sadness of 15% and 16.5% respectively.

There was an increase of over 25% in ocular movement activity during performances in which musicians were expressing elation and happiness.

## 5. CONCLUSION

The studies have generated high-quality recordings of musicians in states from strong emotion to purely expressive. Work is under way on the analysis of behavior, both musical performances and the accompanying multimodal data. These make it possible to study how emotion is conveyed in performance, physically as well as by sound, and the ways in which experienced and simulated emotion differ.

Preliminary results show enough evidence to pursue similar experiments in the future. The use of respiratory response has shown interesting results in emotion recognition experiments [15], and it is suggested as an additional feature to analyze in future experiments.

A set of tools to record, process and analyze kinematic and physiological data during musical performance is being developed and perfected in order to assist and improve experimental procedures in the area.

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# Emotion Description with MPEG-7

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## ABSTRACT

In order for systems to incorporate emotions, a format is required for describing them. MPEG-7 is a multimedia standard based on XML which provides one approach for describing emotions through its Affective Description Scheme. However, more advanced emotion description can be enabled by extending MPEG-7 with new and modified description tools.

## Keywords

MPEG-7, metadata, emotion, affect.

## 1. INTRODUCTION

Measuring, describing, and predicting the emotion related to multimedia content is now accepted as being able to add significant value to multimedia systems [1]. For example, retrieving video commercials according to emotion, where emotional content is abstracted by using a rule-based mapping of perceptual features (e.g. motion and colour) on to emotional categories (action, excitement, suspense, quietness, relaxation, and happiness) [4-6]. Another example is where excitement in video is from low-level features (including motion activity, energy in the audio track, and the density of cuts) which are then presented as excitement time curves [7-10]. In another approach [3], affective features are extracted from multimedia audio content and mapped onto a set of keywords with predetermined emotional interpretations. These labels are then used to demonstrate an affect-based retrieval on a range of feature films. In the ELVIS (Entertainment-Led Video Summarisation) technique [12], video is summarised according to the entertainment value of the content to the user. Since emotions, attitudes or moods are likely to be heightened in proportion to the significance of content to the viewer at the time, the most entertaining video segments should elicit the most significant physiological responses from a user during viewing. This premise is used to yield candidate segments for a stream that summarises the video. As can be seen, for systems to work with emotions, some form of emotion description is required. Recently, the need for a standard description scheme has been identified [13]. Such a scheme enables a range of benefits, such as the sharing and reuse of emotion descriptions and the improvement of processing efficiency [14]. This paper discusses the potential of the leading multimedia standard, MPEG-7, for serving as a description scheme for emotion. The next section looks at the existing Affective Description Scheme within MPEG-7. Then, requirements for describing emotion are considered. Finally, the potential of MPEG-7 for meeting these requirements is discussed.

## 2. AFFECTIVE DESCRIPTION SCHEME IN MPEG-7

MPEG-7 is the leading multimedia standard for describing the features of multimedia content, based on XML, and addressing a broad spectrum of multimedia applications and requirements. Within its Multimedia Description Schemes (MDS) [11], the Affective Description Scheme (DS) serves as one attempt to standardise how multimedia systems may represent emotional metadata. The Affective DS enables description of users' emotional response to various types of multimedia content, such as video segments, semantic entities (e.g. events and objects), and so on. Numeric scores on a scale of -1.0 to 1.0 are used to represent the relative intensity of the affective response with respect to a specified affect type. A set of typical types is provided by the AffectType Classification Scheme (CS) as follows: interested, excited, bored, surprised, sad, hateful, angry, expectant, happy, scared, storyComplication and storyShape. The latter two refer to the intensity of complication in the storyline and the intensity of the story plot. Typically these will be deployed on a per scene basis. An example is given in Figure 1, which shows the representation of the emotion 'excited' and the intensity of its manifestation with respect to two content objects: a son and a wife. In this example, excitement will generally be felt more towards the son than the wife due to the wife giving birth.

```
<Affective>
  <Type href="AffectTypeCS:2001">
    <Name> excited </Name>
  </Type>
  <Score idref="son-id">0.8</Score>
  <Score idref="wife-id">0.4</Score>
</Affective>
```

Figure 1. Example of the use of the Affective DS in MPEG-7.

## 3. REQUIREMENTS FOR EMOTION DESCRIPTION

While the approach above does provide some means for representing emotion within multimedia systems, even enabling reference to particular content aspects, this only applies to a generic group of users rather than specific users. This is because the Affective DS is specified within the ContentDescription abstract top-level type which is used to describe multimedia content entities (e.g. images, videos and audios) and abstractions of multimedia content (e.g. semantic or summary abstractions); it does not describe users. Furthermore, the Affective DS allows only simple scores to be assigned to one or more predefined types,

and the associated AffectType CS does not reflect the set of emotions, let alone emotional categories and dimensions, that researchers would typically employ, making it difficult for uninitiated developers to utilise the emotion description effectively. Consequently, a more advanced approach is required that takes into account a broad range of requirements. Such requirements are typical of those identified by the W3C Emotion Incubator Group with reference to the proposed Emotion Markup Language (EmotionML) [2]. These are summarised in Table 1.

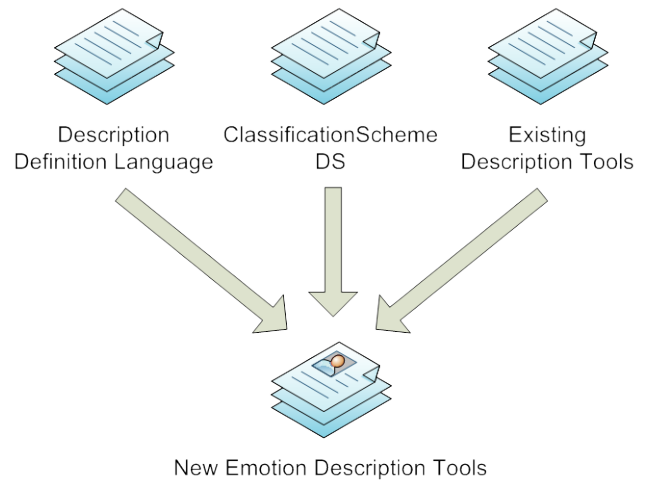
**Table 1. EmotionML requirements.**

| Type of Requirement                              | Mandatory                                                                                                                                                                                                                                                                                                       | Optional                                                                                                                                                                                   |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Emotion Core</b>                              | <ul style="list-style-type: none"> <li>Type of emotion-related phenomenon</li> <li>Emotion categories</li> <li>Emotion dimensions</li> <li>Appraisals related to the emotion</li> <li>Action tendencies</li> <li>Multiple and/or complex emotions</li> <li>Emotion intensity</li> <li>Emotion timing</li> </ul> | <ul style="list-style-type: none"> <li>Emotion regulation</li> </ul>                                                                                                                       |
| <b>Meta-information about emotion annotation</b> | <ul style="list-style-type: none"> <li>Confidence / probability</li> <li>Modality</li> </ul>                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>Acting</li> </ul>                                                                                                                                   |
| <b>Links to the 'rest of the world'</b>          | <ul style="list-style-type: none"> <li>Links to media</li> <li>Position on a time line in externally linked objects</li> <li>The semantics of links to the 'rest of the world'</li> </ul>                                                                                                                       | <ul style="list-style-type: none"> <li>Information on person(s)</li> <li>Social and communicative environment</li> <li>Purpose of classification</li> <li>Technical environment</li> </ul> |
| <b>Global metadata</b>                           | <ul style="list-style-type: none"> <li>A generic mechanism to represent global metadata</li> </ul>                                                                                                                                                                                                              | <ul style="list-style-type: none"> <li>Mappings between different emotion representations</li> <li>Relationships between concepts in an emotion description</li> </ul>                     |

#### 4. POTENTIAL OF MPEG-7

While the existing Affective DS and AffectType CS may be deemed to be rather limited for affective multimedia systems, for the reasons given in the previous section, MPEG-7 is an open standard and therefore provides means for supporting the specified requirements, as summarised in Figure 2. New or modified schema definitions may extend the MDS through the use of the MPEG-7 Description Definition Language (DDL). The DDL is based on the W3C's XML Schema Language but with some extensions to cater for the necessary requirements of audiovisual content. For example, using the DDL, it is possible to define new affective description tools that enable the grouping together of emotion phenomena, the specification of emotion dimensions, such as valence, arousal and dominance, and the use

of standardised emotional intensity scales, such as Hz for physiological responses. Existing description tools within the MDS cater for other requirements such as the need to specify confidences and probabilities regarding the representation. For example, all DSs inherit a Header element, which enables the use of a DescriptionMetadata Header in order to represent such information as the confidence in the accuracy of the information represented by the DS, as well as information identifying the description, describing its creation, the rights associated with the description, and so forth. Likewise, links to media, timelines and semantics are catered for primarily through the Relation DS, which specifies a directed or undirected relationship between a source and target part of the description, of a particular strength and a particular type. The type of the relationship may be specified using any defined CS, such as the SemanticRelation CS which describes 'high level' relationships and includes relevant terms such as (inverse given in brackets): symbolizes (symbolizedBy), depicts (depictedBy), context (contextFor), patient (patientOf), experience (experiencerOf), stimulus (stimulusOf), causer (causerOf), and exemplifies (exemplifiedBy). If the existing CSs defined within the MDS are unsuitable, CSs may be defined, using the ClassificationScheme DS, which incorporate custom terms. Hence, the AffectType CS could also be replaced with a more elaborate and appropriate CS defined by the developer.



**Figure 2. New emotion description in MPEG-7.**

#### 5. SUMMARY

This paper has examined the potential that MPEG-7 has for describing emotions. After a consideration of the standard's Affective DS, the potential for more advanced emotion description through modified and new description tools was discussed. MPEG-7 has the potential to meet a broad range of requirements for emotion description, even though the prescribed representations within the standard are limited.

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# Emotional Video Album: getting emotions into the picture

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## ABSTRACT

Emotions are essential to human beings, influencing their health, their cognition and creativity. One of the greatest strengths of video is its power to generate attitudes and emotions as no other medium can, and it is also an excellent tool for displaying affective information [1, 10]. Video is becoming more and more pervasive in our lives. Technological developments and the trends for media convergence are turning it into a dominant medium. Nowadays, we access video on the web, we capture and transmit it with our mobile phones, and we keep the ones we treasure the most. In this paper, we present the Emotional Video Album, where users collect and interact with videos, based on videos' affective contents and properties, and in accordance with their own emotional profiles, choices or states.

## 1. INTRODUCTION

Emotion studies have been done over the last few years, since it became proved that they are fundamental in cognitive and creative processes. In fact, understanding emotions is crucial to understanding motivation, attention or aesthetic phenomena. There is an increasing awareness in the HCI community of the important role of emotion in human computer interactions and interface design, and new mechanisms for the development of interfaces that register and respond to emotions have been studied [6,11,14,15]. Gathering emotional information from users can contribute to create emotional context in applications interfaces. Rosalind Picard in [18] defends that systems that ignore the emotional component of human life are inevitably inferior and incomplete, and she states that systems that provide a proper and useful social and emotional interaction are not science fiction but a science fact.

In this paper, we explore the emotional dimension in the collection and interaction with videos in the Emotional Video Album. First we review the motivations and foundations of work in HCI and video that take emotions into account, then we present the Emotional Video Album.

## 2. EMOTION IN HCI

An emotional interface is defined by the HUMAINE project as an interface that keeps user engagement through the capacity of perceiving user's emotion, to

adapt to it, to react to it and to initiate it [12]. Donald Norman in his Emotional Design book and paper [16,17] claims that attractive things work better. Interactive systems should be engaging enough to be pleasurable and that positive states of mind make people more receptive to new ideas or even interruptions, arousing curiosity and engagement, while negative emotions make problems look bigger than they are and people more focused, favoring concentration upon detail. He also identifies three different levels of brain mechanisms related with cognition and emotion: visceral, behavioral and reflective, that should be taken into account, and raise different design requirements. Scherer [20] also dissects about the aesthetic emotions explaining that these kinds of emotions are goal and need independent but can be changed over time, and that attractive or aversive stimulus can generate positive or negative feelings.

It is now consensual that emotions influence human-computer interaction, because aesthetic pleasure, engagement and fun are regulated by the human emotional system and are as important as usability or functionality in the interface design [16,21]. The growing interest in understanding how emotions can be explored in HCI motivated the recent creation of an interdisciplinary special interest group (SIG) [6] in this field.

## 3. VIDEO AND EMOTION

Video is a very rich media type, combining diverse symbol systems, such as pictures, texts, music and narration, often engaging the viewer cognitively and emotionally, and having a great potential in the promotion of emotional experiences. It has been used in different contexts: as a way to capture and show real events; to create and visualize scenarios not observable in reality; to inform; to tell stories and entertain; to learn; and to capture and share our collective culture and personal history.

Video can represent emotions and also be an emotion inductor. The work of Alice Isen [13] attested this potential, when she and her colleagues experimented the effect of positive affect in her patients, inducted by ten-minute comedy films. S. Bardzell [2] preliminary results suggest that emotional responses even to short amateur videos are both intense and complex. Other

experiments [1,3,10] showed that video's greatest strength is the power to generate attitudes and emotions, not only because it is an excellent medium to display emotions but also due to its elicitor characteristics.

Some research developments in video indexing and processing are already taking emotions into account. In [14,15], Money and Agius explored the use of sensors for human physiological responses and expressive face recognition techniques to detect user emotions while watching videos. These emotions were intended to produce affective video summaries. Physiological responses were a potential valuable resource, but facial expressions could not be discerned frequently enough to be considered a reliable source of information. In [24] video scenes are retrieved by their emotional content, by an interactive genetic algorithm. Videos are automatically classified with low-level descriptors like shot duration, average color histogram, average brightness, average edge histogram, and gradual change rate. The retrieval process is done by an iterative process that creates new populations of videos by crossover and searching most similar solutions in the video database, based on human evaluations of scene types: action, excitement, suspense, quietness, relaxation, and happiness. Detail-on-demand video was explored by [7] to provide a hyperlink structure of the video content, by summarizing it in short segments, with different levels of detail. This concept could be used to summarize and access emotional content, although it was not explored in this context.

#### 4. EMOTIONAL VIDEO ALBUM

The Emotional Video Album is being designed to explore the affective dimensions of videos in accordance with user emotional profiles, choices or states. These dimensions are reflected in the way we watch our videos and the way we organize, search and interact with them. They are also reflected in the way we chose to organize the videos around the photographic album metaphor, where we collect personal and favorite photos, and with which we tend to develop an affective connection. The video album has two main goals:

- 1) To explore video access mechanisms
- 2) To present the interface

based on videos' emotional content and user emotions.

For this, we need to address the following dimensions: Emotional classification of contents; Emotional content-based access; and Interface design matched with emotions.

##### 4.1 Content Classification

There is a multitude of definitions and models trying to define emotions, but there is no common accepted definition. Everyone knows what an emotion is, until asked to give a definition [9]. Dimensional theorists defend that two or more dimensions can define emotions, like the dimension of valence

(positive/negative) or arousal (calm/excited) [19]. Others admit a set of basic emotions, like the Ekman's [8] six basic emotions of anger, disgust, fear, happiness, sadness and surprise. The psychologist, Klaus Scherer [20] defined emotional descriptors, and presented the Geneva Affect Label Coder (GALC) with a thirty-six affective categories, which allows to explore ways of gathering emotional user profiles and classification of content.

In the Emotional Video Album, we take these dimensions and categories into account, in order to classify video *content*, and *user* emotions.

*Videos* and *video scenes* can be classified and indexed from two perspectives:

- 1) by the *objective emotion* that is conveyed, e.g. a video or a scene showing happy people;
- 2) by the *subjective emotion* that it induces on the user, for e.g. sadness, because the user relates that specific kind of situations with a sad event in her life.

Classification can be done either *manually*, or with the aid of some *automatic* process: through video processing techniques [24] and emotion recognition methods [11] while the user is watching the video. In a first stage, we are exploring manual approaches, where the user identifies the emotions, but intend to experiment with the other approaches, later on.

##### 4.2 Content-Based Access

In the emotional content-based access dimension, we are designing different methods to access and watch the videos, at the levels of the whole video album, and the individual videos, building on our previous experience [3,4,10] with video-based hypermedia spaces.

- 1) *Emotional album views* are created by the indexation of emotional descriptors of the videos, in accordance with different user selections. For example, we may visualize the videos organized by dominant emotions, or we may search for videos emotionally related with a given one, or search for the videos having a specific dominant emotion or valence.
- 2) At the *individual video level*, the video can be presented with an emotional timeline, representing the video's emotions along time, either from a more objective or more subjective perspective. Users can use this information to gain more awareness of the emotions involved, and of how different the two perspectives are, and also to access scenes based on their dominant emotions. Video summaries [7] can also be provided, to present videos in chosen emotional perspectives and preferences, or in response to emotional user states.

##### 4.3 Interface Design Matched with Emotions

To match the interface design with emotions, we are exploring emotional design [17, 23] and design for fun [21, 5, 22] guidelines and insights from previous work.

Fun is associated with positive affects, and has been addressed in design. One example is the work of Ben Schneiderman in [21]. When he claims that users should be engaged with fun features, he is pushing affect and emotions to fun features, which he considered to be: alluring metaphors, compelling content, attractive graphics, appealing animations and satisfying sounds. Chang et al. [5] have explored animation cartoon techniques to conceive user interfaces more engaging with its audience and more easy to understand, because cartoons are theatrically based and engage by its illusion. Thomas and Calder [22] have described how smooth interface changes technique, borrowed from cartoons, improved the visual feedback of a direct manipulation interface and how this kind of effect could bring the sense of substance to interface elements. These techniques give fun properties to interactive interface elements, stimulating user positive emotions. According to Norman [17], rounded shapes, smooth and symmetrical objects, and rhythmic beats, are some of the interface characteristics that also induce positive states; while sudden, unexpected loud sounds or bright lights, darkness, looming and sharp objects, empty and flat terrain, induce negative emotional states.

In the Emotional Video Album, we intend to explore the photo album metaphor, with which we tend to develop an affective connection, in flavors that reflect different contents or user moods, extended with the new interactive access features, in ways that enrich our affective relation with videos.

## 5. ACKNOWLEDGMENTS

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# MoodyPie: emotional photowear for autobiographical memories

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## ABSTRACT

We often remember personal events with strong emotional ties, but can emotional information help us retrieve digital mementos? This abstract presents an exploratory design and a brief evaluation of a functional prototype to help arrange personal digital pictures according to emotional states. We discuss design implications in the light of current psychology and HCI research in emotional memory.

Our aim here is to explore whether these emotional links can improve access to these collections.

## Categories and Subject Descriptors

H.1.2 [Models and Principles]: User/Machine Systems – *human factors, software psychology*. H.5.2 [Information Interfaces and Presentation]: User Interfaces – *user centered design, interaction style*.

## General Terms

Design, Experimentation, Human Factors.

## Keywords

Emotional memory, Photo memory, Digital memory, Emotion and HCI, Autobiographical memory.

## 1. INTRODUCTION

Advances in digital photography mean we have quickly accumulated vast collections of personal pictures that are often hard to access. We know from psychological research that some of those pictures are likely to be more memorable than others due to their strong autobiographical emotional ties [2, 5]. Our aim here is to explore whether these emotional links can improve access to these collections.

Many memory augmenting tools such as MyLifeBits [4] focus on a *time-line* for temporally accessing autobiographical memories.

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Workshop on Emotion in HCI at HCI'08, September 1-5, 2008, Liverpool, UK.

Instead we describe an exploratory prototype and evaluation study where we use an *emotional-wheel* representation to help people organise and re-access their memorable pictures using their emotional memory.

## 2. DESIGN

We designed a prototype MoodyPie which allows photo tagging, organization and re-access using emotions as its principle feature (see Fig 1). Much psychology research [1, 6] uses an *emotional-wheel* with a comprehensive spectrum of emotions. After initial pilots, we abandoned this, because it seemed overcomplex. Instead our interface presents four basic emotional orientations: Happiness, Sadness, Interest and Other. To allow subtleties of personal expression, we also created a textual tagging area for each picture, where people can list all their moods and add other descriptors.

MoodyPie also has a drag and drop functionality, to help people place or rearrange their pictures in a more appropriate mood quarter. We also allow people to place their images across borders of different emotions to show mixed emotions they felt. Finally design aims to capture emotional strength. The core of the circle represents the highest strength of the emotion and the outer areas represent weaker emotional states.

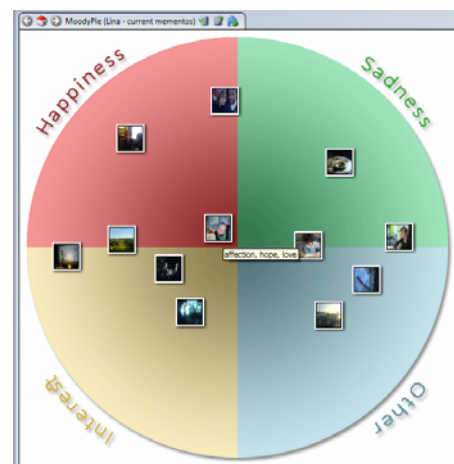


Fig 1. MoodyPie Interface

### 3. EVALUATION

#### 3.1 Procedure

#### 3.2 Participants

We had 3 participants (2 male and 1 female, age range 27 - 37) who used MoodyPie for up to 1 hour each. We asked them to select 30 pictures from their personal picture collections across 3 time intervals (a) Current, (b) About 1 year old, and (c) Older than 1 year. We then asked them to organise those pictures in MoodyPie according to the emotions associated with each and add textual tags to describe their emotional state in more detail. We observed their actions and at the end asked them some structured questions.

#### 3.3 Initial Results

We collected a total of 82 pictures (due to 2 participants not finding enough older pictures). As expected from prior research [7], the biggest portion of pictures were classed in the *Happiness* emotion cluster (see Fig 2) across all time intervals. Naturally people reminisce more about happy memories as they look at their personal albums. We did not observe any difficulties with placing pictures in the *Sadness* cluster, but there were significantly fewer pictures placed there. *Interest* and *Other* clusters were quite popular for pictures that had more complex emotions such as pictures that people thought were “cool” or “felt proud of” (see Fig 2). Importantly for the success of this approach, participants seemed to enjoy looking at their pictures and tagging them in this way.

However our participants found it hard to identify older pictures in their personal collections. Even though they had a vast number of digital pictures, these only dated back 2 years on average and older pictures were in paper format and needed scanning in.

In terms of the relationship between time interval and emotional cluster, it seems that the older the picture, the more likely it was to have a happy association, as one participant said: “...generally the older the picture, it's more likely to be happy even when there are annoying people in it...somehow it becomes more positive”. It may be that emotional attitudes towards digital pictures change over time, but how could we capture this change in our prototype, and would people want to preserve those changes digitally?

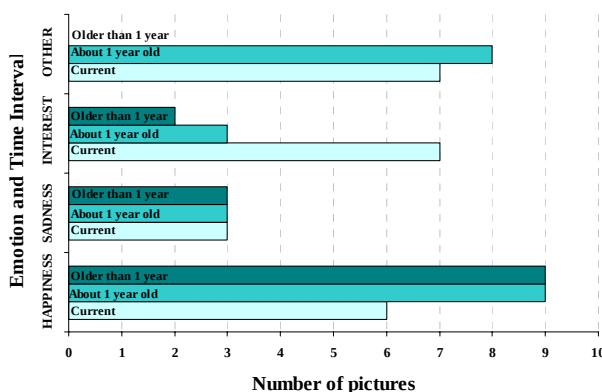


Fig 2. Image Clustering at Different Time Intervals

The remaining pictures were mostly in *Happiness* and *Interest* regardless of time interval. We also collected detailed textual descriptors of emotions for each picture which we are currently analysing.

#### 3.4 Ongoing and Future Work

We are currently extending our study of the MoodyPie prototype with more participants. Of particular interest is whether participants can successfully exploit emotional information for longer term retrieval. By incorporating user feedback we also plan to explore different prototypes using different representations, such a more nuanced *emotional-wheel*. We are also looking to create a new *dynamic* wheel prototype where people could split the wheel in as many dynamic emotional clusters as they need.

### 4. CONCLUSIONS

Overall people found MoodyPie to be an interesting and novel way to look and reminisce through their personal picture collections. One participant said: “when I look at my pictures, I feel lost...there are so many...but [Moody Pie] gave me a direction and helped me reminisce...it's an interesting way of looking at your pictures”.

Rather than taking the standard approach of using temporal *time-lines* [4] to arrange digital memories, we instead explored the use of an *emotional-wheel*. This seems a promising way to guide us through our large picture collections and aid reminiscence. Applications like MoodyPie may also be used to reinforce or change mood state.

### 5. ACKNOWLEDGMENTS

We would like to thank all our participants for taking part in this study.

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# An affective channel for Photopal

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## Abstract

Since some years, computer gives information through screen, the interaction between users and computers has been made by keyboard and mouse. With the maturity of several technologies such as agents, and the maturity of technologies concerning human attributes e.g. visual recognition, vocal recognition other forms of interfaces are emerging, these interfaces are called “Companions”.

‘Companions’ know its owner, they are able to complement their cognitive capabilities and help them to accomplish a lot of tasks.

The interaction with the system, including ‘Companions’, will be done between multimodality systems proposed and distinctiveness offers by the devices.

In order to improve its performances, system responses will take in account the user’s emotional state.

The ‘affective channel’ is an emotive capability of ‘Companions’, which contains: voice, prosody, facial expression body posture , and semantic information according to user’s emotional state. It other words the affective channel of ‘Companions’ do have to change in order to react to every user’s attitude.

## 1. INTRODUCTION

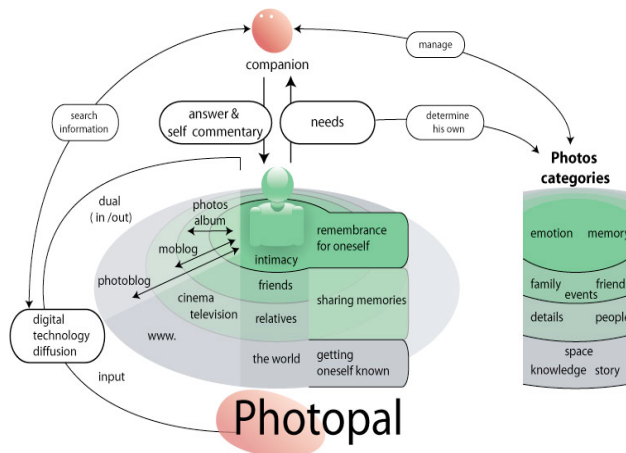
Long-term emotions have not been understood because of Descartes’ legacy (“I think, therefore I am”) which fore grounded cognition as reason. Recent advances in neurobiology show that emotions and reason are absolutely interdependent (Damasio, 1994). The past few years have seen an enormous interest in feelings, which are triggered by objects and artefacts – e.g. Schutte (2005), Norman (2004), Desmets (2002), Jordan (2000), Picard (1997).

“Companions” is a personalized conversational interface to the Internet that knows its owner. It is implemented on indoor and nomadic platforms based on integrated high-quality research into multimodal human-computer interfaces, intelligent agents, and human language technology (Wilks, 2006).

“Companions” are expected to be the next generation of interface technology; they will act as managers for a myriad of services mostly offered by internet. Looked as well as emotional interfaces, the impact of “Companions” with the users are unknown, but the users’ attachment to their “Companion” seems crucial to permit its successful tasks it must accomplish. (Benyon et al, 2008), (Roa Seiler et al, 2008)

The innovative vision and goal of “Companions” is to change interactions into relationships (Benyon & Mival, 2007). The new approach of HCI deals with the user’s experience as a whole. To achieve this and to construct an affective interaction, emotions are inescapable.

## 2. PHOTOPAL



Photopal, the first implementation of “Companions” is devoted to supporting users in their personal photographic practices. Figure 1 illustrates the main functionalities of the service and level of intimacy that owner of “Companion” chooses.

Photopal interacts through everyday language. As the owner relates the circumstances of the picture-taking, it tags the semantic data (date of events, locations, people) and can create photo albums. Photopal can share these pictures with the user’s personal network of friends & relatives by connecting to photoblogs or moblogs

(mobile phone blogs).

‘Kodak culture’ showed us that photo albums are symbols of cultural and structured behaviour (Chalfen, 1987). The impact of images is to ‘freeze’ a series of life rituals such as births, marriages and deaths - so that the user can remember people, events and things significant in his or her life. Memories are not merely souvenirs but recall the emotional state the user has already experienced. Understanding this feeling is crucial in a relationship. The stronger the emotion the more Photopal is needed to build the owner’s confidence. The first empirical work with Photopal focused on elderly people. It revealed that family photography is a major way to collect and organize memories, to transmit them and to give meaning to their lives.

## 3. AFFECTIVE CHANNEL

Since last years, computer gives information through screen, the interaction between users and computers have been made by keyboard and mouse. With the maturity of several technologies such as agents, and the maturity of technologies concerning human attributes e.g. visual recognition, vocal recognition, other forms of interfaces are emerging, these interfaces are called “Companions”.

“Companions” knows its owner, its’ able to complement their cognitive capabilities and help them to accomplish a lot of tasks.

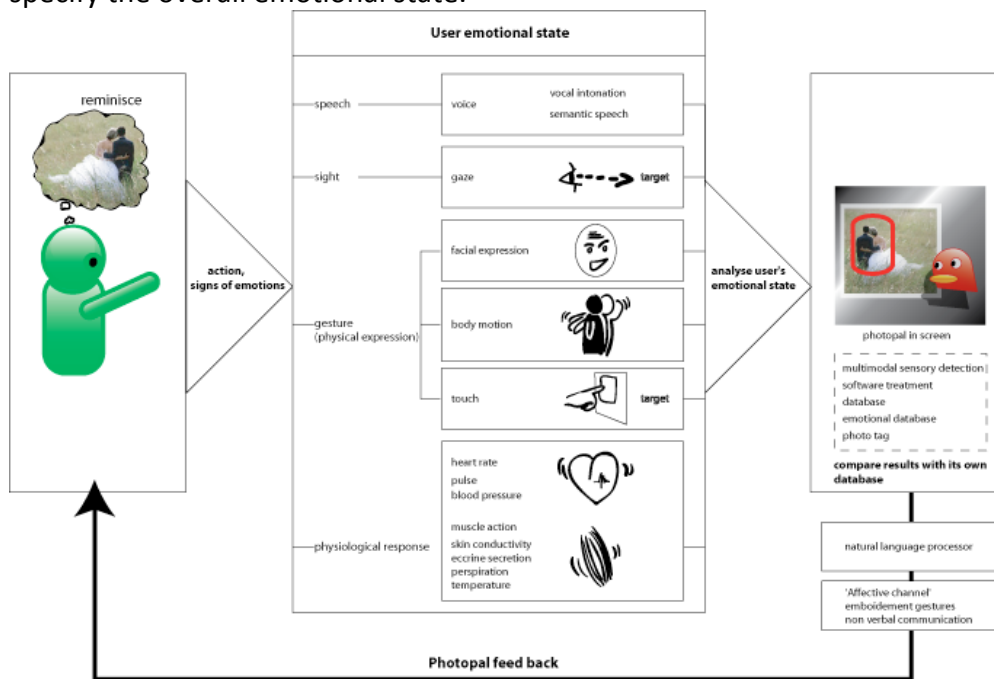
The interaction with the system including “Companions” will be done between multimodality systems proposed and distinctiveness offers by the devices.

In order to improve its performances, system responses will take in account the user's emotional state. It means that system not only detects this state but responds in a way which is easy, friendly but overall relevant to situation user is living. As part of system "Companion" will be able to capture his/her owner involvement with interaction, humour, contextualization, and relevance.

The 'affective channel' is an emotive capability of "Companions" which contains: voice, prosody, facial expression (or presence expression depending of "Companion" embodiment), body posture (if embodiment), and semantic information according to user's emotional state of. In other words the affective channel of "Companion" do have to change in order to react to every users' attitude.

Because the affective channel contributes to the naturalness of interaction it's crucial on the overall success of system.

Figure 2 shows how is expressed the users' emotional state by physical expressions, physiological responses, gaze, and voice. Every factor must be analysed in order to specify the overall emotional state.



Photopal: global analyse of user emotional state

Figure 2

#### 4.CURRENT RESEARCH

The evaluation of Photopal in order to establish its affective channel is currently in progress. This evaluation is expected to inform design of next versions of Photopal in order to improve relationship between Photopal and its owner.

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# Emotion in Video Games: Quantitative Studies?

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## ABSTRACT

The primary reason for which video games exist—be they played on a PC, a game console, or a mobile device—is to strongly evoke and/or control emotional states in the user. Whereas game developers are aware of this, they can hardly find practical-minded but nonetheless quantitative studies to inform their design decisions. To alleviate this situation, we propose to experiment with minor design changes or specifically created ‘levels’ in off-the-shelf, user-modifiable games. We survey related work, report on the proposed study, and point out issues and chances for this strand of research.

## Categories and Subject Descriptors

H.1.2 [Models and Principles]: User/Machine Systems—*Human factors*.

## General Terms

Design, Experimentation, Human Factors

## Keywords

Video Games, Emotion

## 1. INTRODUCTION

Play tests [14] are notoriously time-consuming and hence also tend to be expensive. The effort to conduct exhaustive play tests to learn the effect of specific design decisions can hardly be justified. One needs basic, generalisable research on the relevant phenomena. To this end, we propose to experiment with first-person-shooter games that can be modified (‘modded’). To enlarge the number of subjects and possibly work with online users, we furthermore propose to use inexpensive emotion quantifications.

Overarching designs, in particular those concerning the storyline, are hard to evaluate on the basis of moment-to-moment changes in the user’s emotional state. Hence, we intend to focus on variables with a more local effect, such as

- Illumination: brightness, colour, distribution and type of light sources,
- Scene geometry: spacious halls vs. narrow corridors,
- Music: choice of genre, tempo, style,
- Foley sounds: choice of door slams, footstep noises,
- Speed: velocity of the player and his or her opponents,
- Player’s resources: health, armour, ammunition, etc.,
- Enemies: health and number of enemies.

The settings in a specific game situation may be different for each player. In addition, a player may encounter a specific situation several times during the game. Each time the settings could be changed. This would allow supplanting between-subject tests by within-subject tests.

An inexpensive—though intrusive and/or delayed—way of collecting data about a player’s emotional state is to ask him or her for subjective assessment. For initial tests, we used EMuJoy [19], which originally was created to report emotions in a two-dimensional coordinate system [27] while listening to music. This tool appeared to be suited to our task, but we soon encountered obstacles when trying to assess emotions in video games, to be discussed later.

Upcoming inexpensive biosensors such as the Emotiv EPOC [8] can collect affect data with minimal invasion and continuously in real time. If they gain enough popularity, they could be used in larger online tests as well. In preparation, the data gained through such devices have to be validated and to be calibrated against self-reported assessments.

## 2. RELATED WORK

Frome [11] identifies different ways how emotions could be evoked by a game, namely:

- Game emotions: emotions generated due to winning, losing, accomplishment, and frustration
- Narrative emotions: emotions based on game characters, settings and events; storytelling
- Artifact emotions: emotions of aesthetic evaluation; emotions about the artwork as such

- Ecological emotions: psychological reactions based on experiences in the real world

Multiplayer games exploit a particular way of how to evoke emotion: A substantial number of participants in massively multiplayer online role-playing games plays for interaction with other players, cultivating friendships, and being part of the community. This can reduce the control of the game designer over the player's emotions as compared to the community's influence.

For Järvinen [16], suspense is a fundamental emotion of gameplay because it combines hope, fear and uncertainty. He refers to the theory of Ortony, Clore, and Collins [21], which states that emotions are valenced reactions to one of the three aspects agents, events, objects, and that certain variables such as the 'degree of likelihood' or 'cognitive mismatch' affect the intensity of emotions.

Grimshaw et al. [12] present different theories related to player immersion on which they base a study about sound and immersion in first-person shooter games. The results of the subjective questionnaires in this study indicate that diegetic sound supports players' immersion and flow, whereas music seems to distract from game flow. Grimshaw et al. employed a modified Half-Life 2 game, as we do.

Game designers tend to base emotions in games on storytelling mechanisms (e.g., [10]) and cinematic techniques. Many publications—in particular those targeting the game industry—use non-quantifiable variables and general rules [4, 18]. Callele et al. [5] employ icons such as emoticons and a loosely defined colour representation to lay out emotional intensity maps to guide a game designer.

## 2.1 Eliciting Emotions through Games

Game designers are interested in eliciting specific emotions. Methods from Affective Computing have been applied to study exemplary designs to this end.

Kaiser et al. [17] created a Pac-Man-like game that could be modified through a level editor. Their so-called Geneva Appraisal Manipulation Environment (GAME) allows pseudo-social interaction with a simple virtual character. With the help of the level editor the experimenters could define the occurrence of objects, characters, and events, and change the speed of the game, the number of enemies, and the size of the maze. Kaiser et al. used the Facial Action Coding System (FACS) [7] to let a human observer identify facial expressions. The percentages of users that display a certain intended emotion range from 24 to 98 percent.

In a study building on that of Kaiser et al., Wang and Marsella [30] created an 'Emotion Evoking Game' (EVG), which is based on the open-source game 'Egoboo' [6]. EVG was designed to induce emotions such as boredom, surprise, joy, anger, and disappointment through different tactics:

- Boredom: Build a game level without enemies and with repeating goals.
- Surprise: Make an encounter with enemies overwhelmingly different.

- Joy: Generously reward the player.
- Anger: Betray the player with the help of a computer-controlled character to create an unfair situation.
- Disappointment: Take away all the collected money from the player when his or her character dies.

The facial expressions of this study's subjects were captured during play. Wang and Marsella could successfully identify at least boredom and anger visually through FACS.

Johnstone et al. [15] used a computer game to induce natural emotional speech that followed conducive or obstructive events. The events were accompanied by pleasant or unpleasant sounds. Immediately after such events, the player was asked to speak letters and phrases shown on the screen. The player's voice was recorded to be acoustically analysed later, which let to the observation that a single dimension of arousal may not be adequate to describe the results.

As video games prominently feature both music and images, studies on their effect such as [2, 22] are relevant for games. A strong effect of music on the perception of images and film has been proved in these studies by quantifiable means. As moviegoers know, music can boost the emotional impact of film and it can steer the viewer's interpretation of the pictures by providing context. Music is also widely employed in video games for both of these purposes.

In research about aggressive behaviour induced by games, Anderson and Dill [1] let players 'punish' their opponents through noise blasts. They derive quantitative measures from the intensity and the length of the blasts. The influence of video games on aggression has been researched into for decades, see e.g., [31], which can also be attributed to the political relevance of the topic.

## 2.2 Analysing Emotions in Games

A number of researchers have addressed how to reliably measure the affective state of the user within a game.

Haringer and Beckhaus [13] propose a framework for non-invasive measurement of affect in interactive applications. Their prototype system uses EEG, two-channel facial EMG, blood volume pulse (BVP), galvanic skin response (GSR), respiration as well as infra-red tracking of head, wrists, feet, and torso. The IR tracking is used for emotion recognition but also facilitates detecting artifacts of other sensors such as EEG. In addition, video and audio recordings of the subject are prepared. The current prototype also uses self-reporting emotional states by the user to calibrate the system. Their framework is to be seen as a modular, scalable approach to affective user state assessment.

Ravaja et al. [23] examine the effect of four specific events in a non-violent bowling game. They argue that the heart rate (HR) reflects both emotional arousal (increasing HR) as well as information intake and attentional engagement (decreasing HR) and hence may not be an optimal measure of arousal for games. Their measurements of heart rate (HR), GSR, and facial EMG activity show that these data in combination produce reliable results. The same research group

has recently repeated this study with violent games [25]. In another study, Ravaja et al. [24] employed self-reporting through questionnaires to examine the effect of four video games from a broad variety of genres. The results indicate that popular video games do not necessarily elicit positive emotions (joy) or elicit strong emotions at all.

In a unique approach to combine emotion measurement and induction by games, Saari et al. [28] propose a ‘user-controlled emotional regulation’. According to their design, both data acquired from biosensors as well as preferences set by the user influence the game’s content and presentation.

### 3. PROPOSED STUDY

There have been many studies about eliciting and measuring emotions in games or other media. Yet, the understanding of how emotions are induced best and how they are to be measured differs a lot. It is not clear to the practitioner how his or her decisions concerning the design of a game are reflected in the user’s affective state. To help with this situation, we propose inexpensive but large-scale experiments with user-modifiable video games.

#### 3.1 General Approach

Currently, this topic seems much more complex than other realms of human-computer interaction. For instance, the time a user needs to click on a menu entry can be estimated well by Fitts’ Law [9]; the reading speed for a given typeface at a given size is available from the literature as well. Admittedly, it does not seem plausible that Affective Computing can come up with similarly precise quantitative results. However, we envision a chance to help game developers balance design decisions in a more quantitative way rather than using only their gut feelings.

The overall effect of a game may be hard to measure precisely and may be hard to trace back to specific design decisions. Hence, we want to focus on effects that occur on a time scale of seconds, not minutes or hours. For easier evaluation, we want to limit the studied effects to single-player situations. This does not, however, preclude the tested game from offering multi-player situations elsewhere.

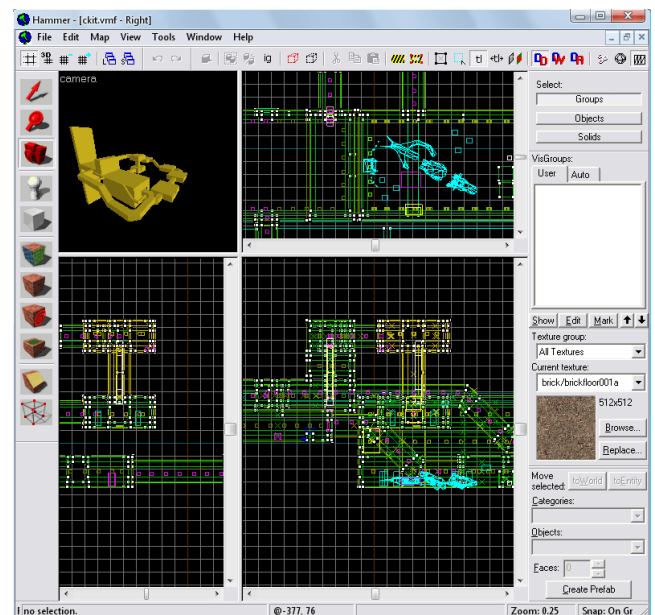
Using the complex context of a user-modifiable off-the-shelf game allows creating meaningful situations, as opposed to abstract test settings that employ extremely reduced and thus unrealistic environments. Pilot tests have to show which of these two options produces more relevant results. Complex content may make it harder to generalise the result: The observed effects may be confounded for instance by the general context (Is the player frustrated about an earlier mishap in the game level?) or by details of the setting (Does the player carry a flashlight to find his or her way through the dark dungeon?). One way to deal with this is to apply similar changes to a number of situations in the game and then examine if the effects tends to be similar.

#### 3.2 Testing Environment

We have begun working with the game engine Valve Source [29], which was used to create several high-rated games such as Half-Life 2 and its sequels. The Source engine is still used to develop games, for instance the upcoming Half-Life 2: Episode 3.

Although it is possible to view and edit the source code of the engine (written in C++), we want to focus on smaller changes that do not require editing the code and thus do not require recompiling the game. Hence, we use the level editor ‘Hammer’ that is part of the software development kit available for download after a purchase of Half-Life 2, for instance. This editor is sufficient for many of the proposed changes and is relatively easy to handle, given a basic experience with 3D modelling tools.

Hammer, see Figure 1, allows placing game objects as well as enemies and allies (non-player characters, NPCs), both of which are computer-controlled. With adequately prepared game levels, a few mouse clicks are for instance sufficient to change the hue and the brightness of all lights on one map, which is interesting for first experiments. Sounds can be replaced; background music or ambient sounds can be added to the scene. To vary the difficulty, the equipment of the player and his or her enemies can be changed easily. However, it is not possible within the level editor to change the player’s and opponents’ locomotion speed.



**Figure 1: The editor Hammer allows building and tweaking game levels.**

We plan to release the test levels of our study together with a small documentation that explains changes of lighting, ambient sounds and amount of enemies, even without knowledge of 3D level editors. The levels are meant to be run in Half-Life 2, which is currently available for about US-\$ 20. So we aim for a small starter-kit that allows modifying variables easily and provides a quick introduction to the SDK.

The idea of this study is not limited to the Source engine. Nowadays, many games can be modified to some extent by their users. The advantages of the Source engine are that it provides state-of-the-art visuals, is easy to handle, and has a huge community that provides support. One even finds free geometry that can be included in new projects. A drawback

of the engine is that it is underperforming with huge outdoor areas. For such purposes, other engines such as the Crytek CryEngine 2 are suited better.

Apart from building game levels to seek and destroy enemies, it is possible to create virtual environments in which players interact with friendly NPCs to simulate social interactions and observe problem-solving. The Source engine is capable of creating animations and facial expressions of NPCs to simulate their moods. NPCs can also ‘talk’ recorded audio messages to the player and to other NPCs. However, the player cannot answer, in contrast to role-playing games. On top of that, to build dialogue sequences requires some effort; it may be easier to study social interactions in games that are more focussed on player-player interactions.

### 3.3 Measurement

In contrast to related work reported before, we propose to trade the high measurement precision that an (overly?) expensive laboratory offers in for the large number of participants that could be handled in lightweight tests, possibly even conducted over the Internet.

A vital issue of the proposed research is to embed the measurement of emotion as little invasively as possible in the game. The gameplay must not be disturbed strongly because otherwise the player’s immersion will be broken and the collected emotion data will be tainted. Because of this, we were thinking about an inexpensive way to collect the data and thus thought about using self-reporting tools.

An implementation of the Affect Rating Dial [26] would have been one option. This evaluation in hindsight is not invasive, but may lead to differences between the actual game experience and the reported emotional state. The size of this effect has to be tested by a small number of better-equipped experiments. Another possibility to look into is to provide quick and frequent self-reporting input from the user during the game. To this end, one could try to integrate tools such as the Self-Assessment Manikin [3] into the game’s user interface. We expect, however, that the data input inhibits the original flow of the game. The size of this effects is yet unknown and would have to be determined in selected situations with a limited number of subjects.

Collecting emotion data through self-reporting may require anchoring examples such as the International Affective Picture System (IAPS) to place the data in a coordinate-frame that is independent of the user.

In our first experiment, we invited a small group of participants to play some specially devised game levels. Their gameplay was constantly recorded by Half-Life 2’ internal recording functionality. After the end of each run—which was either determined by the avatar’s death or the end of the level—the recorded video was shown on the same screen inside the game environment. On another screen, next to the main screen, the player then rated his or her emotions during playing the level using EMuJoy [19].

Whereas this setup surely provides a cheap and easy-to-use system for the player as well as the researcher, it displays some flaws that taint the data: In this particular environ-

ment it was not possible to show the gameplay video and the evaluation tool simultaneously on the same screen. This led to the unfavourable situation that the player had to switch his or her focus constantly between the video and the tool. This could be avoided if the rating tool was provided within the game engine or if the video was played within the tool. EMuJoy already allows loading videos into the application, but this requires exporting the game data into proper video files. Since this takes too long, the player cannot assess his or her experience right after playing. Another problem can be the mapping of complex emotions into the two-dimensional space employed by EmuJoy. At least for one player it was not intuitively possible to rate his emotions in this space and it seemed that he was more concerned with the process of rating than about re-evaluating his emotions.

For reasons such as these, one may abandon self-reporting and instead look at the patterns of preference and avoidance exhibited by the players: If players tend to pick a specific game item with positive power in the game over one with negative power, this may indicate a certain mood, similar to the noise blasts of Anderson and Dill [1]. To correctly evaluate emotion from such choices may require complex upfront tests with more sophisticated emotion measurements to construct the underlying statistical model.

Since self-reporting cannot provide continuous and non-intrusive emotion measurement during gameplay, we consider to use inexpensive biosensors such as the upcoming Emotiv EPOC [8], an easy-to use EEG cap intended for game applications. Emotiv’s announcements and demonstrations have already stirred much interest so that this device may become highly popular. In future, even off-site participants in an online test may have it at hand.

According to the information published so far by Emotiv, the software development kit ‘Affectiv Suite’ signals emotional states such as excitement, engagement, boredom, and frustration in real time. These names, however, may not perfectly reflect the experienced emotion. Thus, cross-validation with results of a self-report tool is compulsory.

A simpler, single-channel EEG-based gaming input device that is already available to OEM manufacturers is NeuroSky MindSet [20]. Its output of levels of two brain states called ‘attention’ and ‘meditation’ may, however, be too coarse for reliable emotion measurements.

Objections are put forward for instance by Zeng et al. [32] that the projection of high-dimensional states into a 2D space causes a loss of information by rendering certain emotions indistinguishable or by disregarding emotions that may lie outside the space. On the other hand, Parke et al. come to the conclusion that a ‘three-dimensional vector space of stress, activity, and dominance is a reasonable and continuous representation of human emotion’ [22].

### 3.4 Expected results

Modifying games or using their engines to test the effects of interaction and audio-visual environments opens up many opportunities for research into emotion and cognition. Games do not only allow testing the influence of different settings easily but may also help in cross-validating different

measurement methods, as they offer many ways of human-computer and human-human interaction.

To tweak single parameters such as illumination or scene geometry may or may not have significant effects onto the player's emotions. The proposed simple testing may enlarge the number of subjects, but this need not suffice to observe small effects. Such indifference results would, however, also be instructive for game design. It may well turn out that boosting the player's emotional experience does not require keeping an eye on every variable.

The results may also tell us more on how to evoke and control emotion in serious games and in general applications. The proposed study is also intended as a preparation for similar experiments based on professional EEG or even on fMRI brain scanning.

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# Issues In Evaluating Emotional Responses Within Interaction

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## ABSTRACT

This position paper describes current issues in evaluating emotional and affective aspects of interaction. The role of qualitative interaction factors varies from system to system. Defining this role helps us to understand what is significant about emotional experience within interaction, in the context of user and organizational values. Much of what we seek to know is not available to direct probing, due to its essentially tacit nature. Therefore direct probing or simple measures of emotional response will not get to the essence of what we need to know.

## General Terms

Design, Human Factors, Theory,

## Keywords

Emotion, evaluation, tacitness.

## 1. INTRODUCTION

Emotional factors in interactive systems require new evaluation approaches. In this relatively new field it is unclear as yet whether this entails an entirely fresh approach or modifications to existing approaches. The aim is to support the iterative development of systems by giving designers and other stakeholders meaningful insights into cause and effect relations related to qualitative experience. A number of tools have been tried thus far to assess affective factors in interaction. Product reaction cards [1] prompt users to identify 'attributes' present in a product, some of which are user experience attributes, pairing their emotional responses with a subset of preset terms. The reactions imbue the product with descriptors reflecting the user's experience of them. Variants on that concept allow a non-verbal expression of mood by selection from a range of cards bearing alternative facial expressions [8]. Other approaches allow users to experience a product, eliciting their reaction using a greater level of psychological probing. These include the use of Repertory Grids and Card sorting [3,5]. A questionnaire-based approach described by Hassenzahl [4] invites the user to express affective responses to products by rating them by various criteria on bipolar scales (e.g. interesting—boring). A further approach tests the galvanic skin response of users during interaction.

## 2. THE PHENOMENA OF INTEREST

Emotional responses may be the object of the system, for example in a game or entertainment system. In other examples they are intimately bound up with system goals, user values and organizational values. Perhaps the goal of a design is to produce a simple non-instrumental emotional state (joy, fun?). Perhaps the goal is to produce a set of behaviours, and this is a goal that is

shared with the user (e.g. persuasive technologies such as diet assistants). Perhaps the qualitative experience of interaction for the user is not the goal in using the system linked to instrumental goals (e.g. e-banking). In each case, emotional responses, their stimulation and consequent effects are a critical component of interaction and in turn key design and evaluation phenomena.

Games and entertainment applications could be seen as having the goal of a good user experience, of positive felt states. Therefore the experience is the key goal, and any notion of the instrumental is subsumed within the affective. By contrast a diet mentor is a persuasive technology [2]. Part of the system's role is simply information provision, but its presence, its ability to affect the mental state of its user, persuading them to keep their discipline and providing encouragement in this, is central to its value.

In the case of e-banking the goals and values of participants are separate but linked, and issues of user experience have a subsumed, instrumental role in it. The aim of the organisation is to establish and maintain a trading relationship with the customer. In order to do this they need to establish and maintain a trust relationship with potential clients. Previous work [3] demonstrates that tangible as well as intangible factors affect the users perception of whether or not an organisation is worthy of trust. Interaction may give users a sense of confidence, or a sense of unease, suspicion or resentment that they can report. The reasons for that suspicion could in some cases be satisfactorily explained by tangible factors, and directly articulated. However, the affective intangible dimension may not easily be evaluated.

## 3. UNDERSTANDING TACIT FACTORS

Evaluation of emotional factors in interactive software faces the issue that much of what we want to know is in the tacit dimension. Thus understanding cause and effect is a complex task for evaluators. The most simple, traditional notion of tacitness is knowing that cannot be made explicit through verbalisation. In Polanyi's words [7] 'we know more than we can tell' citing examples such as face recognition and bicycle riding where sophisticated ability to perform contrasts with a marked inability to explain. We have natural aptitude for these things that seems to be beyond our conscious understanding. Polanyi's assertion is that knowledge is different from knowing, knowing being more a process than a state. Humans do not track the causality of their mental states. First-person attempts to describe and account causally for emotional events are inevitably flawed and unreliable.

#### 4. EVALUATING EMOTIONS IN CONTEXT

Useful information about emotional responses should have the goal of reliably understanding cause and effect. A qualitative reaction in the user may be effected by a good design. Equally the design goal may be to produce a particular response in terms of behavior and attitude, with qualitative experience playing a pivotal role. Therefore understanding causality is a crucial goal. This suggests that direct approaches where subjects retrospectively explain their responses may be limited in value. Explicit and retrospective accounts of tacit behavior are likely to be reconstructed and unreliable. The role of technologies that assess affective states in evaluation strategies is as yet unclear, but it is clear their use has limitations. It is unlikely that physiological responses can be reliably paired with aspects of the design in a way that explains cause and effect in depth. That an emotional response has occurred simply denotes an issue. Two possible ways forward are triangulation and a change of perspective towards approaches from the arts. Triangulation means the use of multiple empirical methods to build a portfolio of persuasive evaluation evidence. So approaches such as observation, galvanic skin response measures and self-reporting can denote issues, or phenotypes. More probing approaches such as repertory grids can be used in tandem to further understand and reason about the denoted design issues. The argument for more arts-based approaches are that experience is not a measurable, quantifiable phenomenon, and approaches such as art criticism may get closer to the essence of it.

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# Affective Response to ICT Products in Old Age

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## ABSTRACT

People are living longer and the world population is ageing. At the individual level, ageing leads to functional losses and causes behavioural changes. In combination, these factors affect the quality of product interaction. However, in many cases design itself unnecessarily compromises interaction by failing to consider the needs of the user.

To better understand the user a literature review was carried out. This included topics on interaction and on the physiological, psychological and sociological aspects of the ageing process. It was then hypothesised that there is a dominant level of response for users in different life stages – sensory for youth, cognitive for younger adults and affective for older adults. A multi-stage study was designed, and in the first stage (on which this paper reports), interviews were conducted with older and younger adult. Results confirmed that in general younger adults easily understand how to use ICT products such as computers and mobile telephones, because the cognitive demand imposed on this user group corresponds to their abilities. In contrast, for the older adults the sensory and cognitive demands did not match their abilities. These users have more difficulties in understanding and using this range of products. Consequently, older adults avoid the use of mobiles and computers when they are not motivated to do so or believe that no satisfaction can be achieved. Further study on other age groups (e.g youths) is planned for the near future.

## Categories and Subject Descriptors

K.4.2 [Computers and Society]: Social Issues

## General Terms

Design

## Keywords

Ageing, Affective Response, Interaction

## 1. INTRODUCTION

The population of people aged 60 years old and above is projected to reach nearly 2 billion in 2050 [1]. Promoting social integration and independent life through technology is a way of improving older adults' well-being. It is also important in order to keep the resources that are required to provide special care at sustainable levels. A mobile phone, for example, can bring confidence and the sense of ubiquitous safety and independence to elderly people living alone, as long as these users are able to accept and use the product. The quality of interaction is therefore critical to the uptake of technology. However, for many older adults, the digital divide is difficult to bridge as products like computers and mobile telephones are frustrating and alienating. Moreover, these products are often simply not attractive for the older population. This could be due to the fact that, currently, older adults are expected to adapt to ICTs in a techno-deterministic view, instead of being involved in the creation of socially shaped products [2, 3]. Consequently, although older adults might greatly benefit from what these technologies offer, they are often discouraged from adopting them because of unsatisfactory experiences with products. Design that elicits positive emotional response motivates and empowers people and makes life more meaningful. It also potentially optimizes older adults' information processing and improves performance in cognitive tasks [4]. Moreover, "positive" design that connects people, transforms the ultimate goal of independence and valuable social interaction in later life into an achievable experience.

This paper provides, first, an overview of the ageing process on its four dimensions: physical, sensory, cognitive and affective. The intention is not to give a comprehensive description of ageing but to focus on the aspects that influence the user experience. Secondly, it reports on an exploratory study into the usage of electronic products, in which users in two age bands were interviewed – younger adults, aged between 25 and 35, and older adults, aged 65 and over. These age ranges were chosen because they mark the transition in users' social roles [5, 6]. For this study, this meant that the younger adults would typically be at the point of entering or establishing themselves in professional life, whilst the older adults were typically at the point of retirement or withdrawal from professional life. The study addresses how user experience varies between the two age groups with respect to the four dimensions of ageing mentioned above. The findings from the study are therefore also discussed with respect to these four dimensions, each of which corresponds to a different level of user experience.

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## 2. BACKGROUND

Ageing is described by Strehler as universal, intrinsic, progressive and degenerative [7]. It leads to behavioural adaptations caused by gradual changes in physical, sensory, cognitive and affective responses. Therefore, it is important to understand these responses, how they may influence one another, and how they affect people's well-being, especially at advanced ages.

### 2.1 Physical Ageing

According to Kirkwood and Holliday [8], ageing results from an accumulation of damage in the cells as a consequence of limitations in maintenance and repair along life. Although ageing is an intrinsic biological process, it is mostly an artefact of developed societies, where forces of natural selection are less relevant [9]. The downside of living longer is that age-related diseases, such as diabetes, cardiovascular disorders and neurodegeneration to name just a few, affect an ever-growing number of older adults and have become the major causes of morbidity and death in the Western countries [10]. These diseases constitute the main cause of disability in later life, compromising older adults' well-being not only physically but socially and emotionally as well.

### 2.2 Sensory Ageing

In order to interact with the world around us we use our senses. As we age, changes in the nervous system contribute to the slowing in processing of sensory stimuli and of motor and sensory conduction velocity [11]. Moreover ageing of the sensory system's body tissues causes a gradual decrease in the intensity of sensation.

The five classical sensory functions in our bodies are taste, smell, touch, vision and audition. The ageing of these senses takes place at different rates but it usually presents more drastic implications, such as loss of functional abilities and independence, after the sixth decade of life. For the older population this represents an increase in risk of nutritional problems and fire hazard due to reduced ability to detect and identify taste and smell [12]. Risk of falls also increases as a result of a decrease in foot tactile sense [11] and an increase of visual impairments [13]. Higher incidence of car accidents among older drivers has been reported as well due to reduction in the field of view [14]. A decline in the quality of social and emotional life has been attributed to frustrated communications resulting from hearing loss [15] which also increases with age [16].

### 2.3 Cognitive Ageing

Development is a lifelong process [17]. It is assumed that any developmental change includes both time growth and decline in adaptative capacity, since no developmental change during the life course is pure gain. Cognitive development, like any process of development, entails an inherent dynamics between gains and losses with mechanisms of compensation. According to Baltes's theoretical framework of adaptative cognitive functioning, general knowledge and specific knowledge in areas of expertise can increase across adulthood [18]. Such expertise can even offset cognitive decline [4]. However, the conditions must be such that people can actively select what tasks they believe are capable of accomplishing, according to their motivational and cognitive

resources and skills [19]. One form of compensation is known as plasticity of development. It refers to learning gains and designates the potential that individuals have for development after instruction and practice [20].

Recent studies suggest an interrelation between changes in sensory, sensorimotor and cognitive functioning, and that this interrelation is intensified by ageing [21].

### 2.4 Affective Ageing

The capacity to control emotion is important for human adaptative functioning and largely determines the impact negative events will have on our mental and physical well-being. In a study on emotion and ageing, Gross and colleagues found that age is associated with diminished intensity of emotional impulses, a concomitant lessening of outward signs of both positive and negative emotional expressions, and increased emotional control. Therefore, in spite of declines in cognitive abilities, age does not impair emotional control. Generally, older adults demonstrate greater emotional control, higher or at least sustained levels of positive affect, and report fewer negative emotional experiences [22].

Applying Baltes's theoretical framework to the social context, Carstensen developed the so called *Socioemotional Selectivity Theory* [23]. Findings in Mather and Carstensen's work [24] suggest that because older adults realize their "time is running out" greater focus on emotional goals among older people lead those in this age group to favour positive and avoid negative information in their attention and memory, even though automatic emotional attention processes, such as threat detection, change little with age. As a result satisfaction with life increases or is maintained, relationships with family are described more positively and even rates of depression and anxiety are lower among older adults [4]. Thus, the ratio of positive to negative affect improves through adulthood [24].

### 2.5 Hypothesis

Based on the literature this work proposes four levels of response. These levels correspond to the four dimensions of ageing: physical, sensory, cognitive and affective. The hypothesis is that as we age, and lose and gain abilities, we tend to use different levels of response more intensely in different life stages. Therefore, for each age group there would be a dominant level of response: sensory for youth, cognitive for younger adults and affective for older adults. To explore this hypothesis an exploratory study was carried out. In the first two phases of this study only the two older groups were considered. A third phase, in which users under age 20 will be interviewed, is planned for the near future.

## 3. METHODOLOGY

Volunteers were recruited from two Cambridge-based organisations – the University of Cambridge and the University of the Third Age (an independent organisation that arranges courses and study groups for its members, most of whom are retired). Six younger adults and eight older adults took part in the study. With the exception of two older adults, members of both groups completed higher education in a variety of disciplines. The

sample is consequently biased towards intelligent, literate and education-oriented individuals. The limitations of this sample are discussed later.

Informal semi-structured interviews, notes and photographs were used for data collection. All interviews were conducted by the first author on a one-to-one basis, took place at the interviewees' homes at a pre-arranged time, and were audio recorded. Participants were encouraged to talk generally about electronic products they own, and specifically about the product that they regard as most important to them.

Notes were then made from playback of the interview audio recordings and these were combined with the notes and photographs taken during the interviews. By reading and comparing these materials, a number of common themes were observed allowing similarities and differences between the two groups' experiences to be identified.

## 4. FINDINGS

The various themes that were identified during data analysis were grouped under the four levels of response – physical, sensory, cognitive and affective. Because the interviews all centred on the products that the participants identified as being of most importance to them, discussion of these four levels of response is preceded by a discussion of product selection.

In detailing product selection and response, our focus here is not only on the material product, but on how ageing influences the way in which people at different stages in life experience technology and how design can contribute to this. To do this, the behaviour of one group is often best explained by contrasting it with the behaviour of the other group. In the sections that follow, the attitudes and behaviour of younger and older adults is described with respect to the sample, and not as a generalisation to the broader population (for a discussion of how future studies will address a larger sample see the Limitations and Future Work section).

### 4.1 Product Selection

Participants were asked which products they use on a daily basis. They were then asked to choose only one product, which was the most important in their opinion. Four younger adults opted for their laptop computers as their most important products. The remaining two adults decided to talk about their mobile telephones because, as they explained, talking about their computers would be “just too obvious”.

Among the older adults, six participants described their computers as the product they use most frequently. One older adult preferred to talk about the radio and another participant regarded the telephone – mobile and landline – as the most important electronic product. (It is, however, important to clarify that these two interviewees had a different life-style from the others in this group. The one, who chose the radio, never had children, lives alone and likes to listen to non-music radio programs as a form of companionship. The second, who chose the telephone, is 75 years old, who suffers from a degenerative disease and is therefore in a wheelchair, and said that without the telephone it would be

impossible to manage keeping in touch with friends and family, and organizing outings.)

### 4.2 Physical and Sensory Levels

As expected, these two levels of response did not receive much attention from participants. Therefore the findings were combined in the following paragraphs.

Despite the lack of attention, there were two main issues in these levels of response. Both younger and older adults complained about the weight of laptops and batteries. Those in the first group explained that the weight is important since these users frequently carry their computers when they travel, whilst those in the latter group who use a laptop chose this more compact form of computer hardware not necessarily for its everyday portability, but simply because they occupy less space in their residences and are easier to transport when maintenance is required.

The second issue was raised by older adults who complained about the difficulty of typing on keyboards and keypads that had small keys and that were labelled with small letters or numbers. Two older participants, who reported being unable to type fast/accurately, said they have tried different keyboards in order to minimize typing discomfort and mistakes.

*“The one thing I’m finding these days is that these keys (mobile keypad) are getting so small I do have difficulty to make sure I pressed the right key.”* Participant J, age 70.

### 4.3 Cognitive Level

At this level, findings were mainly clustered in two groups – usage, and learning and memory.

#### 4.3.1 Usage

Although computers and mobile telephones can be used for many personal tasks (e.g. media player, games, organiser, diary, alarm), it was clear that all participants favour these products' (inter-personal) communication functions above their other uses. All interviewees who talked about computers claimed that the first thing they do after turning the product on is to check their email. Generally, the use of computers was considered by both groups more important than the use of mobile telephones.

For five of the younger adults, their products are not just a device for communication and work. They are also a way of organising daily tasks, entertainment and shopping.

*“Apart from being a communication tool, my mobile is my organiser as well. I have my contacts on there, write notes, I organise my business and social meetings, and I keep a list of things to do.”* Participant D, age 27.

*“I’m addicted to the Internet. So the first thing I do after turning my laptop on is to check my emails. But I also use it for work, entertainment and e-commerce to buy books, flight and train tickets, for example.”* Participant F, age 34.

In general younger adults have various applications open at the same time – email, text/video chat, web browser, media player, and one or two applications specific to their work. They usually

carry their notebooks when travelling, even when they are not working, as they see the computer as an indispensable part of their lives.

In contrast to the younger adults, the older adults did not always have a clear opinion about technology products. Often, during the conversation, they spent time recollecting memories in an effort to make sense of a product in their lives. Basically, older adults use technology for communication. In the case of computers, those in this group reported that they seldom use more than three applications simultaneously – usually an email client, a web browser and a word processor.

*“I think I’d say I use the computer...most of the use I make of it is like a very clever typewriter.”* Participant L, age 71.

One exception to this was a particularly active older adult who said he uses at least three other software products for desktop publishing and sometimes also uses video chat applications.

#### 4.3.2 Learning and Memory

Regarding the ability to learn how to use the product, younger adults said they never read manuals or use customer service. They learn by “playing” with the product and if they have any doubts they usually ask friends. Moreover, these younger adults seldom had memory problems and reported that once they have learned a task they can repeat it with no difficulty.

*“I learned [how to use my laptop] by myself. I cannot be bothered to read manuals most of the time. Sometimes I ask friends when they are around. But I don’t go out of my way to seek help.”* Participant B, age 26.

In general, older adults find most manuals poorly written and therefore not helpful. When asked about how they learned to use their products, three users in this age group said they attended courses, in the case of computers; three said they usually ask children or friends; and two said they try to learn by “playing” with their products. All older adults reported memory problems and said that if they do not use a function for some time they easily forget how to repeat it.

*“Usually manuals are poorly written. But every so often I have to go to ‘help’ and I go also to ‘help’ online because I can’t remember how to use a function.”* Participant H, age 69.

However, participants in this group demonstrated that if well-trained, they can benefit from technology if it allows them to compensate for any decline in their functional abilities.

### 4.4 Affective Level

At this level, findings were grouped in five themes – motivation, meaning, arousal, appraisal and attachment.

#### 4.4.1 Motivation

Among all users, the main motivation to use computers was the ability to communicate with family or friends living away. However, when this motivation was absent, older adults said they did not see any particular reason to use a computer.

*“I’m sure that if I had children I would know how to use my computer.”* Participant I, age 69.

#### 4.4.2 Meaning

When asked what the chosen product meant to them, younger adults mentioned abstract qualities such as ‘freedom’, ‘peace’ and ‘safety’, and more concrete qualities such as ‘productivity enhancer’ and ‘organiser’.

Because technology is more integrated in younger adults’ lives it has consequently a different meaning for this group: it is a need, as all younger adults answered they could not live without their computers and Internet. This need is present in different dimensions of life – such as personal relationships, work, information, entertainment and hobbies – and is necessary to the maintenance of these dimensions.

Older adults, in comparison, see technology from a different perspective: it is a possibility, not a need, of doing things faster. When asked the same question, only one older adult considered the product as a toy; two answered that they regard their products (radio and telephone) as companions; one said it was a servant; and four said their products were just tools.

#### 4.4.3 Arousal

When questioned if they were or have ever been afraid of using the product, three younger adults answered that they were excited instead and the other three simply said they were not afraid. Among the older participants, only one reported excitement when first using the product; four older adults said they were not afraid, and three answered they were frightened.

#### 4.4.4 Appraisal

Regarding satisfaction or frustration towards the chosen product, two younger adults said they were frustrated; two said they sometimes get frustrated; and two said they never get frustrated. In this age group frustration is in most cases caused by high demands from the user on the product functionality although it could also be attributed to poorly written help functions and instruction manuals.

*“I got frustrated once, but I was very advanced. I wanted to install a second operating system. It took me forever and in the end it didn’t work.”* Participant A, age 26.

*“There are moments I get frustrated. Especially when I have a lot of applications running at the same time and of course some of them might freeze and I have to disable them; or if the wireless system goes does, then that would also be pitiful.”* Participant E, age 33.

Among the older adults, one interviewee said he gets very frustrated; one said only ‘yes’; and the other six reported that they occasionally get frustrated when using their products.

*“I get very frustrated with the computer because if I don’t know what to do next I get stuck.”* Participant N, age 92.

Among all interviewees who talked about their computers, those who use Apple products associated this brand with less

frustration. They added that the system is more intuitive and additional applications and peripheral devices are easier to install, i.e. the cognitive demand is lower.

#### 4.4.5 Attachment

Younger adults are less attached to their physical products in the sense that when they need to upgrade their devices they easily dispose of their current product. In comparison, older adults tend to accumulate products.

Regarding the technology, the younger adults said that they cannot imagine life without a computer and feel safer when they have all their personal data, such as organiser, diary, music and videos, close to them. Participants of this group also associated “freedom” with the laptop, once they can connect to the Internet “anytime anywhere”. In contrast, seven out of eight older adults responded they could live without their electronic products. For this age group, life without computers and mobile telephones is easily possible, sometimes even a relief. Only the participant in the wheelchair said life would be extremely difficult without the telephones.

*“Pen and pencil I use, and a telephone. I can’t relate to anybody who wants my email, my website, nothing like that.”* Participant M, age 75.

## 5. DISCUSSION

In general younger adults easily understand how to use ICT products because the cognitive demand imposed on this user group corresponds to their abilities. Younger adults in this study reported being capable of learning by themselves how to use this range of products, as they never read instruction manuals. This could be due to the fact that younger users’ mental models do not differ much from designer’s mental model since most designers are younger adults as well. For this group, the use of computers and mobiles is not limited to communication – work, entertainment and management of daily life are also important. Therefore, ICT is well integrated in different dimensions of their lives.

In contrast, older adults have more difficulty in understanding how to use this range of products. Often, the poor quality of interaction leads older adults to develop fear, frustration and more negative than positive feeling towards the product, although this age group can deal more successfully with negative feelings than younger users. As a result, in the cases where the cognitive demands are too high, the product is merely seen as a useless artefact.

For older users, computers – not to mention mobile telephones – are rarely associated with joy and satisfaction. Four of the older adults indicated that they are conscious of how their way of thinking is different from those who create and develop these products. They complained that if designers paid more attention to these users’ actual needs, electronic products would be more understandable, usable and useful, and the overall experience would be more pleasurable.

Lastly, most older adults questioned the need for so many features in a computer or mobile telephone, saying that they actually seldom use more than the basic functionality of their products.

## 6. LIMITATIONS AND FUTURE WORK

The interviews reported on here were conceived as a pilot study that sought to explore how ageing influences the experience of ICT products. Whilst it has been successful in that regard, the study is also limited in certain ways. Firstly, the small sample reported on here is not representative of the broader population, because of its socio-economic settings and literacy level. Secondly, the study primarily relied on the participants’ self-report and made only supporting use of other data collection methods such as contextual observation. To make generalisations across the broader population, and to establish whether the participants’ accounts correspond with their normal behaviour further work is required.

As a next step, a questionnaire survey is currently being carried out. The intention is to reach users from three generations – under 25 years old, their parents, and grandparents. Results will then be analysed and compared with the results from the interview study.

With the survey completed, it is hoped that the understanding of the specific needs of users in different life stages can be achieved. Based on this understanding, design guidance can be then developed for the purpose of designing better products, which could potentially lead to higher rates of technology adoption among older users and bring gratifying experiences into their lives.

## 7. CONCLUSIONS

This study indicates that younger and older adults have different needs and expectations with respect to product functionality. The degree to which these needs and expectations are met generates feelings such as attachment, satisfaction and excitement or fear, frustration and avoidance. The sum of these feelings makes up the so called affective response, and according to its positive or negative nature, this response will determine the acceptance and use of a product and, beyond that, will determine the acceptance and use of the technology incorporated by the product.

From the findings reported above, it was possible to conclude that communication is considered the most important need by adults of different ages. Thus, technology which fulfils this need tends to be more readily adopted. The adoption rate is, however, different for younger and older adults. As this paper has shown, this difference in adoption may result from variation in the dominant level of response between the two groups.

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# Emotional Agents as Software Interfaces

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## Abstract

The background discussed in this paper is intended to form a basis when evaluating agents with a broad range of emotional characteristics in a variety of applications, including computer games, simulations and the web. The need for such an evaluation has arisen as a consequence of working with software developers who were implementing agents with emotions using the authors' emotional architecture E-AI. Whilst working with these developers it became apparent that as well as providing an architecture, evaluation guidance was also required in order that the implemented emotional agents were performing as expected and thus worth the investment in time to develop further. The intended outcome of this work is to begin looking at how differing evaluation methods can be combined or used in conjunction to provide a broad evaluation methodology suitable for commercial developers.

## 1 Introduction

There has been much published research on the benefits of adding aspects of emotional behaviour and appearance to agents in games and simulations in order to improve the immersive experience for the user. This research predominantly encompasses three areas:

1. Agents that behave, and alter their behaviour, seemingly from experiencing an emotion [Gratch et al 2004] [Bartneck 2002].
2. Agents that exhibit aspects of emotions visibly, including facially, through body postures, or vocal changes [Eckschlager et al 2005] [Stern et al 1998], but without any substantial artificial intelligence (A.I.) controlling the changes.
3. The users' emotional response to emotional agents in these applications.

Whatever the intended outcome, the developer will need some method of evaluating the effectiveness of the implementations in order to satisfy the objectives of the project, and this is further complicated if they require a combination of outcomes, that can encompass a range of disciplines including HCI (Human Computer Interaction), usability, psychology and software development.

## 2 Background to Investigation

The E-AI architecture has been specified for developers who may not wish to tie themselves into one of the currently available cognitive architectures such as CogAff<sup>1</sup>, Emile<sup>2</sup>, SOAR<sup>3</sup> and Tok<sup>4</sup> that traditionally combine their emotion components into the primary cognitive model. Each of these architectures has proven merits and strengths, but traditionally games developers use in-house libraries to fulfil agent behaviours and as such need guidance on how emotions can be incorporated into their own software solutions. With this in mind E-AI is grounded in formal psychology and includes salient aspects of common architectures to provide guidelines and a

specification to developers in the broad area of emotions. It brings together non-conflicting theories of emotion and clarification to much of the common terminology, such as moods, feelings and emotional categories [Slater 2007]. The architecture is built around the six stage emotional process [Scherer 2005] as shown in figure 1.

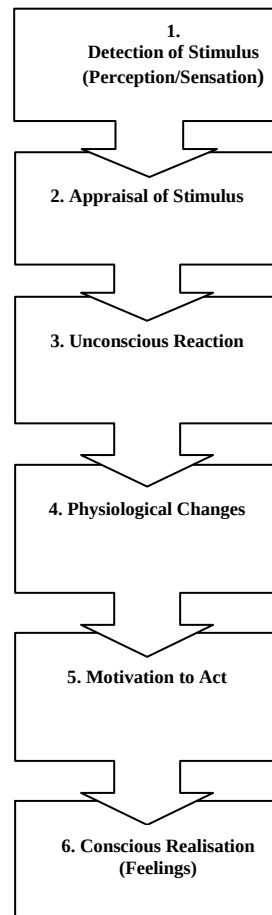


Figure 1 – E-AI six stage emotion process

Subsequently the E-AI architecture was provided to a developer looking at investigating agent social interaction (emotional) using Id Software's Quake 3 game engine<sup>5</sup>. Though the developer succeeded in their objective, when discussing the results it became apparent that it was exceedingly difficult to evaluate the agents' emotional performance.

With further commercial opportunities arising, it became clear that the architecture would need complementing with a formalised evaluation methodology specifically aimed at agents with emotions. A secondary aim, was that it was hoped that the strategy could steer developers when faced with design choices. With this goal, research was conducted in the area of emotion evaluation in the areas of psychology, HCI, usability and software development.

<sup>1</sup> <http://www.cs.bham.ac.uk/research/projects/cogaff/>

<sup>2</sup> <http://www.isi.edu/~marsella/webpapers3.html>

<sup>3</sup> [http://sitemaker.umich.edu/soar/soar\\_at\\_um](http://sitemaker.umich.edu/soar/soar_at_um)

<sup>4</sup> <http://www.cs.cmu.edu/afs/cs.cmu.edu/project/oz/web/papers.html>

<sup>5</sup> <http://www.idsoftware.com/>

### 3 An Overview of Psychology Techniques for Evaluating and Measuring Emotion

Traditionally psychologists use two methods for evaluating and measuring emotions, these are observation by a trained observer and secondly self-reporting by the individual. Techniques such as the Facial Action Coding System (FACS) [Ekman et al 1975] are used to allow a researcher to have a level of confidence when observing participants during experiments involving emotional responses. Alternatively during self reporting it is common for participants to fill in questionnaires on how they are feeling under certain controlled conditions. This self reporting has been shown to uncover emotional states that are not easily observed such as jealousy and resentment. This subjective reporting complements other work using vocal and word cues to assess emotions and emotionally linked states such as depression and anxiety [Wells et al 1994]. Once the data is gathered a method of statistical analysis is normally conducted in order to interpret the results.

### 4 Evaluation Techniques Applicable to Computational Models of Emotion

Evaluating models of emotion would seemingly be fundamental to proving whether or not the agents in these games and simulations actually exhibit the human like emotional responses that the developers intended. Subsequently there has been some published evaluation of computational models of emotion including:

1. Evaluations of specific architectures by the original developers.
2. Independent evaluation techniques that can be applied broadly across computational models of emotion.

#### 4.1 Specific Architecture Evaluation

Gratch and Marsella have documented [Gratch et al 2004] methods of evaluating their Mission Rehearsal Evaluation project (MRE) by comparing the behaviour of agents within MRE, against what is known about real human behaviour in similar circumstances. By having reference data [Gratch et al 2001], the researchers were able to compare the performance of the agents against the expected behaviour (baseline data), rather than having to involve a range of participants to comment subjectively on what emotions they were actually witnessing within the virtual world. The actual data was derived from the Stress and Coping Process Questionnaire (SCPQ) [Perez et al 1992] which is used to measure a subject's response to coping against a baseline of what is expected of "normal" human behaviour. The results showed potential flaws in the agents that may have been missed from observation alone [Gratch et al 2004]. Alternatively Reilly used the Em System [Reilly 1996] to develop seven agents who were programmed with a level of emotions and autonomous behaviour. These agents were then presented to seventeen users for around twenty minutes, who observed the agents within the same simulation, with and without the emotional aspect activated. The order of interaction with the agents was changed to avoid repetitious behaviour, and after the experiment was finished, each participant completed a questionnaire, part of which asked them which emotions they may have observed. The participants were not scientifically screened or selected for their knowledge of emotion observation skills. Users were asked to rate agents on a scale from 1 (unemotional) to 7 (emotional), after which a statistical t-test (a method used to assess statistical significance of data) was used to analyse the data.

In other research [Selvarajah et al 2005] the use of questionnaires has been used to evaluate the interaction of a player controlled avatar in a virtual world, where for much of the time the player's avatar is ignored, commonly called the "cocktail effect". This type of simulated social situation is useful for evaluating an individual's

emotional response to social disclusion, and typical questions included "Do you think this room contained guests controlled by actual humans?" In this research, two simulations were developed, the first used scripted agents (i.e. they could simply show seven facial expressions only, without concern for the emotions of others around them), the second simulation featured agents with more autonomous behaviour. The two simulations featuring the agents were given to a group of participants to evaluate on believability. In the simulation only the seven emotions proposed by Ekman [Ekman et al 1975] were included in the game agents expressions and behaviour. These seven emotions were anger, surprise, fear, disgust, happiness and sadness and neutral.

The experimental details included a group of forty nine participants, whose responses were gathered via a series of questionnaires. Question areas included:

- Identify agent facial expressions - the purpose of which was to evaluate whether the participant can differentiate between the seven facial expressions suggested by Ekman.
- Complete questionnaires on believability in both simulations, to provide comparative data for the investigators.

A similar approach was used with the emotionally developed agent Lyotard, where the validity of the emotion model was evaluated by observers commenting on the agents' observable behaviour [Bates 1992].

#### 4.2 Independent Architecture Evaluation

In the paper entitled Measuring Emotions, Pieter M.A. Desmet [Desmet 2003] discusses the development of the Product Emotion Measurement Instrument (PrEmo). This research involved comparing two traditional methods of evaluating emotions:

- Non-verbal techniques such as observing subjects visually or taking galvanic skin responses.
- Verbal techniques such as subject self reporting.

The outcome of this comparison led to the development of PrEmo, a tool to help users identify their emotions when evaluating products and software. PrEmo includes the capability to measure fourteen emotions, which are divided between seven pleasant and seven unpleasant emotions, as shown in figure 2.

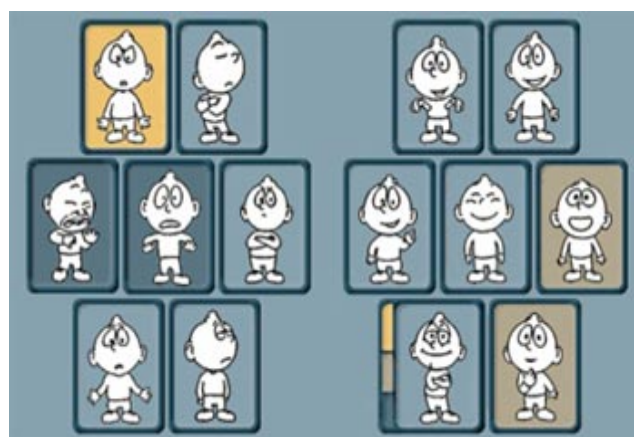


Figure 2 showing fourteen Images from PrEmo [Desmet 2003]

Users interact with a piece of software and report their emotions based on clicking an animated image of the character who they think best shows their own emotional state. Images rather than words were used as a prompt for users, because according to the research, images were thought to be more transferable across cultures.

The work has subsequently been used in conjunction with the marketing of products commercially, where users are shown

products, and then asked to identify how they feel by choosing the appropriate image [Desmet 2004].

The developers of the Virtual Petz games [Stern et al 1998] used the observe-only approach when developing their in game agents for the Petz software. The developers specifically wanted their users to only be able to relate to their virtual pets through the pets physical and behavioural appearance and chose not to give any other indicator of the pet's emotional state, such as textual cues as to how the pets were feeling.

Though the two methods mentioned earlier, both rely on human interaction either by a trained observer or a user's subjective reporting, *The Face Reader* project [Zaman et al 2006] added a third alternative, automatic appraisal of facial emotions via a software solution. The software is able to distinguish seven emotions identified by FACS (discussed earlier) and is reported to have a high accuracy rate. The developers used the QUIS questionnaire<sup>6</sup> to evaluate the usability of the software.

## 5 Evaluating Agents from a HCI & Usability Perspective

Assuming agents in games and similar applications can be categorized as software, and furthermore a type of software interface, then applying formal usability evaluation techniques to them, would seemingly be central in order to ensure they meet end user requirements. The use of formal usability techniques to evaluate software implementations of emotions (especially in agents), may not be the first approach adopted by some commercial developers, but this may need revisiting in light of much of the research work conducted in software usability over the last two decades, coupled with a lack of emotionally endowed agents in commercial games and simulations.

There is wide support for the notion that one of the biggest factors contributing towards user satisfaction, concerns the user interface [Torres 2002]. Assuming that the interface is the medium in which a user interacts with a piece of software, then if developers expect users to interact with emotionally endowed agents [EEA's], then these same agents need to be evaluated as software interfaces, including traditional techniques and metrics that provide feedback from end users such as:

- Conventional and comparative usability tests.
- Suitable questionnaire development including screening questionnaires.
- Modular and final evaluations.

The previous sections have shown that formal psychology observation and evaluation methods are being used to assess the responses of participants within a range of software solutions, some of which embed aspects of emotion and behavioural change within the agents in these applications. Though these techniques are used to evaluate the human traits in these examples, all of the techniques mentioned are software solutions, and as such ideally require some evaluation of the software from a HCI viewpoint to ensure that the end users are interacting with not only agents with emotions, but usable interactive solutions.. With this in mind there are several well known HCI heuristics such as Nielsen's Heuristic [Heim 2008] which provide clear pointers on what aspects systems developers should focus on when trying to assess end user satisfaction.

## 6 Snapshot of Evaluation Techniques

The discussion presented up to now, highlights a range of techniques across several disciplines that could be used to evaluate different aspects of both human subjects and software agents. These techniques can be summarised as:

1. Evaluation of human emotions by psychology researchers (including subject self reporting).
2. Evaluation of software agents featuring aspects of emotion.
3. Evaluation of the believability of agents in games and simulations by researchers.
4. Evaluation of playability with improved software agents.
5. Usability of software interfaces including HCI Considerations.

These five categories are shown with the salient features tabularised in Tables 1,2,3 and 4.

| Table 1<br>Traditional psychology methods used to evaluate human emotions |                                                                                                      |                                                                                                                                                                                                                                     |                                                                                                                                                                                                 |
|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Who is Assessing?                                                         | Assessing What?                                                                                      | What is the Goal?                                                                                                                                                                                                                   | How Do They Do It?                                                                                                                                                                              |
| Trained Observer                                                          | Physical signs of human emotion i.e. facial signs, vocal signs, galvanic skin response, posture etc. | To ascertain whether or not emotions are being experienced by the individual based on physical signs. There is evidence to support the notion that this is more accurate when only assessing the seven emotions suggested by Ekman. | Clinical observation by a trained individual. Either observer asks questions and observes responses or observation and questions conducted by two or more people.                               |
| Trained Psychologist                                                      | Emotional response of individual under clinical conditions.                                          | To help individuals understand their own emotions, or help them control an underlying emotional problem.                                                                                                                            | Ask open questions to get the subject to talk about, and understand their own emotions. Also used to treat underlying emotional problems.                                                       |
| Researcher relying on test subjects to report their own emotions.         | How well a subject is able to ascertain their own emotional state?                                   | To see if an individual can realize they are experiencing an emotion, then articulate the type of emotion. This has been shown to reveal other emotions such as depression and anxiety.                                             | Self reporting via questionnaire or log book i.e. Asking subjects to record how they feel at a particular time, or asking subjects to write down their changing emotional state during the day. |

| Table 2<br>Methods used to evaluate agents incorporating emotional aspects. |                 |                   |                    |
|-----------------------------------------------------------------------------|-----------------|-------------------|--------------------|
| Who is Assessing?                                                           | Assessing What? | What is the Goal? | How Do They Do It? |

<sup>6</sup> QUIS questionnaire measures effectiveness, efficiency and satisfaction within usability studies

|                                                                               |                                                                                |                                                                                                                     |                                                                                                     |
|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Researcher trying to create emotionally responsive agents.                    | Whether the emotions added to the agent, function the way they intended.       | Creating agents with human like emotions and evaluating the agents on their emotional behaviour and/ or appearance. | Human participants (may or may not be trained) commenting on the emotions they see from the agents. |
| Developers and researchers creating agents with an emphasis on believability. | Whether software and modelling additions to agents, make them more believable. | Assessing how agents can be made more believable.                                                                   | Human participants commenting subjectively on whether the agents are believable.                    |

**Table 3**

Methods used by commercial game developers (testers) implementing more interactive agents (NPC and Bots).

| Who is Assessing?                                                         | Assessing What?                                                                                       | What is the Goal?                                                                                                 | How Do They Do It?                                                                                   |
|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Games Developer                                                           | Whether additions (features added) to agents improve interaction for the end user.                    | Deciding if the software features added to agents, add to game play for the end user.                             | Utilise games testers and beta testers.                                                              |
| Games Tester                                                              | If the agent breaks the game.                                                                         | Playing the game repetitively, to try and identify flaws in interaction.                                          | Ensuring that agents' behaviour doesn't break games.                                                 |
| Beta Tester (Play Tester)<br>These testers typically represent end users. | If the game is fun and playable. Can identify bugs that have been overlooked during in-house testing. | To ensure that the game developed, and features it contains, will be received well by end users prior to release. | Feedback on the agents in respect of playability and interest from a typical end user point of view. |

**Table 4**

Methods used to assess the usability of software interfaces

| Who is Assessing?                                       | Assessing What?                                                | What is the Goal?                                      | How Do They Do It?                                                                                                                                                        |
|---------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Software Developer                                      | Usability of software interface.                               | Deciding if the interface meets end user requirements. | Compare the final interface to the initial specification to ensure that the interface meets the end user's initial requirements. Ensuring interface meets HCI guidelines. |
| Usability/HCI specialist utilizing end user interaction | The usability of the interface from an end user point of view. | To ensure the interface suits the typical end user.    | Typical end users interact with the interface and comment on it, via questionnaires. They may also be observed using it.                                                  |

It is proposed that these five categories could be combined as shown in figure 3 to formally evaluate many aspects of agents with emotions to ensure that they are not only suitable for the application, but received well by end users, immersive in use and actually exhibit the level of human-like features (emotions) the developer intended.

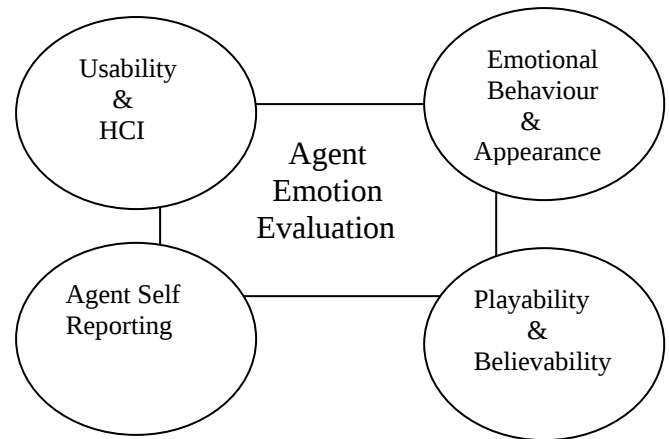


Figure 3 A four way approach to evaluating agent emotion.

## 7 A Four Way Evaluation of Agent's with Emotion

The proposed four-way evaluation relies on the notion that extensive system testing has occurred before the end user evaluates the system. This prevents the users' experience being affected by bugs and crashes that should have been removed (or at least minimized) by the developer. This approach allows the end user to report on their subjective experience of the interface rather than being annoyed or fixated on the stability of the system.

Managing the users' expectations is important, and thus it should be clear to developers and users alike, whether the user is expecting:

- An agent with emotions, interacting within its virtual world.
- An agent that appears to behave as though it is being controlled by a human player and thus reflecting real human emotions independent of the virtual world.

### 7.1 Usability and HCI – Agents as Well Thought out and Designed Interfaces

There is a clear need to ensure that the designs for emotionally enhanced agents are both well implemented and not over laden with features that might adversely affect a user's experience. To fulfil this requirement, an evaluation is required that can encompass HCI and usability evaluation techniques, to ensure these emotionally enhanced agents meet the needs of the target application and subsequent user expectations. This evaluation will minimize ego driven design, and instead focus efforts on producing a suitable end user experience. To this end developers should ensure that the agent's emotion capabilities fit the target application and end user expectations, to avoid over engineering.

Evaluation strategies should allow for scenarios with and without the agent emotions activated and possibly evaluations of the agents, in and out of the target application. This multi aspect testing would provide a more objective assessment of the contribution the emotional enhancement makes to the overall usability of the application.

Typical areas to address would include:

- Do the emotional enhancements function as the user expects them to?
- Do the various agent emotional enhancements get in the way of a user interacting with the software?
- Agent emotions should not adversely affect the time it takes for the agents' decision making process (response time) to complete.

- Do the emotional enhancements add to the overall experience for the user?
- Are the agents behaving as the user expects?
- Are the visual signs of agent emotion as the user expects?
- Is it easy to see what effect the emotions have on the agent?
- Is there consequently a user emotional response to the agents' display of emotions, i.e. a level of empathy or noticeable user emotional interaction? A system like PrEmo [Desmet 2003] could be used to evaluate whether the user is experiencing an emotional response from the agent, or to identify what emotion they think the agent is experiencing. Alternatively a suitable questionnaire could be used [Plutchik 1980], that is designed to assess human emotional states.
- Can the user ascertain what emotion an agent is experiencing, and understand how they are expected to interact with it?
- Is the agent consistent in its emotional behaviour?
- Does the agent consistently behave as the user expects?
- Is the agent implementation buggy, making errors, or the application crashing?

## 7.2 Playability and Believability – Agents as Interesting and Immersive Elements

It is not surprising that commercial game developers favour playability over believability within the games they produce. Terms such as “smoke and mirrors” are often used to identify aspect of games that have been implemented to reduce development and processing time, but still give the illusion to the user of more sophisticated features, such as using 2D images to represent 3D objects as in the practice of bill boarding. Playability is also highlighted with the common practice of job adverts favouring programmers, testers and designers who play games, so that the software is developed by typical end users. This practice of using typical end users to evaluate games (finding bugs and commenting on playability) prior to release is an approach that is not so distant a concept from the common view that “testing and validation has to be done with the purpose of the model in mind” [Ritter 2004], in these instances to sell games that consumers want to buy.

So if commercial developers favour playability over computational realism then the following question will need to be addressed in order for a wider adoption of emotionally responsive characters in games:

- Does the emotion in the agents make the game more playable and or enjoyable for the end user?

This of course is difficult to answer until developers begin integrating emotions into agents and evaluating the end users response.

## 7.3 Emotional Behaviour and Appearance – Agents that Appear Human

When the desired level of agent emotion has been identified and subsequently implemented, then a scientific approach to evaluating the implementation can be undertaken. This evaluation should involve an in-depth evaluation of each emotional aspect, and how they interact to produce more complex behaviours. This evaluation will require the formulation of specific questions that evaluate each component part, how it operates, and the expected outcome. It is suggested that this conforms to the typical formulation of a hypothesis and the usage of independent and dependant variables to ensure that variations in users and situations can be later analysed as part of the final results. This data can be subsequently cross checked against the agent self reporting to evaluate whether or not an observer has correctly identified the specific response of the agent.

Further work in this area suggests the need for reference data that could be used to provide expected outcomes from emotional behaviour and interactions, some work has already been conducted in this area [Gratch et al 2004]. This data could provide a baseline of data for future experimentation and development in emotionally endowed agents.

## 7.4 Agent Self Reporting – Agents That Can Interact and Respond

Emotions have three aspects, physiological, i.e. observable body changes that happen unconsciously to the individual, expression, i.e. facial changes that appear and can be read in social context and private experience, what the individual feels as a consequence of the emotion [Knapp 1963]. Therefore we can only observe what we can see and the private reflection can only be ascertained from a subjective response by the individual. Couple this with evidence to show that observable agent states beyond the basic six emotions of anger, sadness, surprise, fear, disgust and happiness have been shown to be difficult to ascertain as well, then ideally agent self reporting needs to be integrated into software solutions. This self reporting should rely on in-game variables that can be subsequently mapped to what is known of typical emotional states and responses such as emotions and moods. The self reporting data can then be statistically analyzed in conjunction with a human observer to evaluate the agents' emotional states using traditional psychology techniques and remove the need for trained observers to evaluate the agents' emotional behaviour.

## Final Words

There exists considerable research in making agents that can perform tasks more efficiently, agents that are developed to mimic human like behaviour, and agents that have extensive features that might make them useful in solving a range of issues faced by computer users. This research is necessary for the continued development of interactive agents, but what of non-business users? The home user? Gamers? Would the applications they interact with be accepted better by users if the agents they contained were more emotionally responsive? If so, then a multi disciplinary approach is required to properly evaluate these agents to meet these criteria, and this will require extensive work in not only applying suitable evaluation techniques in each of the areas identified, but how the final results are analysed to decide if the implementation is appropriate.

## Next Steps

At the present time the E-AI architecture is being used in a project involving chat bots within Second Life.<sup>7</sup> This project involves adapting currently available chat bots, developed by Daden Ltd<sup>8</sup> (a virtual world consultancy), who provides amongst other things, chat bot's for commercial organizations wishing to have an autonomous virtual presence when company employees cannot be online. These chat bots can take on a variety of appearances (as shown in figure 3) and are intended to be a point of contact and information for companies when people visit their virtual locations.

<sup>7</sup> <http://secondlife.com/>

<sup>8</sup> <http://www.daden.co.uk>



Figure 3 – Chat Bot in Second Life

These chat bots vary in complexity but are capable of answering questions that are commonly asked of real human avatars (avatar is the virtual character controlled by the user). The work that is currently underway is to provide an emotional aspect to these agents in both gestures and behaviors to enhance the usability of the chat bots by visitors. The hope is that visitors will be more comfortable talking to a chat bot that seemingly behaves like a real human avatar. The evaluation techniques discussed in this research are being adapted for this project in order to measure the effectiveness of the final implementation.

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# **Emotion in HCI – Designing for People**

Proceedings of the 2008 International Workshop

## **Editors**

Christian Peter, Elizabeth Crane, Marc Fabri, Harry Agius, Lesley Axelrod

## **Content**

Emotion influences both human-human and human-computer interactions in most of our daily experiences. They affect our physiology, facial and bodily expressions, decision making, and social interactions, and are what make our interactions human. As computing is changing and becoming increasingly social in nature, the role of emotions in computing has become ever more relevant and commercial. This volume provides an account of the fourth workshop on emotion in human-computer interaction, held in the frame of the British HCI group's annual conference in 2008.