The Illusion of Life Revisited

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Abstract

A Virtual Learning Environment (VLE) was supplemented with affective artificial study companions to aid summarisation. To motivate students the companions were made believable by implementing opposite 'affectations' or behaviour-based believable personalities realised as animated agents. The agents were carefully evolved through the use of a user-centred Wizard-of-Oz (WoZ) approach then subsequently evaluated in terms of their pedagogical and affective effectiveness. Finally, conclusions were reached for future work such as the utility of the behaviour-based approach particularly in relation to pedagogical agents.

Keywords.

Study Companions, Affect, Virtual Learning, Personality, Subtle Expression, Design, Summarisation, Evaluation.

1 Introduction: Bringing Characters To Life

In order to create socially meaningful relationships with animated characters designers have attempted to imbue a sense of emotive content upon their creations. Thus it is hoped that a person viewing the character will, for instance, empathise with its distress or be thrilled by its elation, all adding to the 'realism' of the portrayal. In other words the affective qualities of the character are being communicated to the human counterpart in much the same way as affective human interpersonal communication. Such communication is of primary concern not only in traditionally viewed areas such as Film-Making (Thomas & Johnston, 1981) but more recently and relevant to this research, Education (Barker, 2002).

1.1 Research Context

Chapeltown and Harehills Assisted Learning Computer School (CHALCS) is an out-of-hours school situated in a deprived, multi-ethnic inner-city area of Leeds in the UK. This research involved a collaboration between CHALCS and the Computer Based Learning Unit (CBLU) at the University of Leeds. The broad aims of the research were to firstly help widen provision at CHALCS by introducing Internet connectivity then secondly enhance this provision through the use of a Virtual Learning Environment (VLE). Specifically, this research provided course materials in a new part of the Advanced Level (Post-16) Physics curriculum, notably Astronomy and Optics. These materials were contained within the chosen VLE, WebCT, and were developed and delivered in conjunction with an appropriate pedagogical framework (Barker, 2000; Barker & Pilkington, 2000). However, during extensive evaluation of the Physics VLE it was observed that the Key Skill of summarisation was badly supported by the integral WebCT tools. Hence, further studies were undertaken, involving CHALCS' and other schools' students, to inform the development of a summarisation tool utilising collaborative learning with animated pedagogical agents (Johnson & Rickel, 2000) as a means of motivation (Lester et al., 1997) and increased engagement. This would lead to the novel application of animated agents supplementing an off-the-shelf VLE.

1.2 Affective Communication in Characters

In characters, affective communication can be partly achieved through the careful kinaesthetic adjustments of a character's body cel-by-cel, using traditional animation techniques, or in terms of complex three dimensional models in modern computer animation. In the former instance a designer may mimic their own movement and subtle expressivity in order to facilitate a conveyance of affective qualities, adjusting a virtual mannequin slightly during each frame of video (Lucas & Hales, 2002). Or, taking this idea a step further, a designer may digitise an actor's movements then map these onto the character in order to convincingly portray human or indeed animal movement, for example walking or running. However, some researchers have taken the emotive agenda further by combining advances in real world computer models, for example, inverse kinematics (Perlin, 2002) or facial coding systems (Fabri et al., 2002), with models of emotional experience such as the OCC model of cognitive appraisal (Ortony et al., 1990). The result is intended to be a computer-based character which not only appears to act in an emotionally convincing manner but does so as a result of 'thinking' and 'feeling' in a correspondingly appropriate way.

1.3 Design-Based and Model-Based Approaches to Character Design

However, the work described here is based on the hypothesis that strictly modelling the cognitive basis of emotional indicators, for example non-verbal behaviour (NVB) or speech intonation, is not necessarily a precursor to creating socially meaningful interactions in computer-based characters. Instead it is posited that by carefully manipulating the manifestations of affective cues in computer characters, such as NVB and speech, it is possible to create the *illusion* of an underlying emotional life. This does not necessarily mean that approaches based on affective models are redundant as this approach is obviously of worth in more open-ended and less deterministic applications such as adjusting a character's affective state depending on the affective state of a human or synthetic counterpart (Hudlicka, 2002). The intention though is to show that a design-based approach to expressivity can be as effective as a model-based approach, particularly in a constrained environment such as our research context. However, admittedly this approach is not without its limitations leading to the possibility of combining the two approaches.

2 Creating The Illusion

As mentioned, in order to create the illusion of life in our synthetic characters one pivotal notion is to create a sense of emotive experience as portrayed by the character. There are of course other concerns for successful characters such as characterisation, sound design and story but the focus for the moment is on creating *affective* and *believable embodied* agents.

2.1 Affect

There has been much interest over recent years in an area of Computer Science which has come to be known as Affective Computing (Picard, 1997). Basically, it involves taking into account affect in computer systems, be it in terms of making computers aware of user's affective states (e.g. in Human-Computer Interaction) or modeling affective states within a system (usually employing Agent-based approaches). By recognising user's affective states it is hoped that a system can be more empathic and symbiotic. By modeling affective states within a computer it is hoped that artificial cognition will begin to more closely mimic human cognition. The latter could lead to modeling affective states of artificial (animated) Agents thus creating a more 'believable' character (Bates, 1994).

Damasio (1994) argues convincingly for the importance of the integration of mind and body in describing mental life, what Columbetti (2001) calls 'strong embodiment'. Picard (1997) decomposes emotional systems into five components: Emotional behaviour, Fast primary emotions, Cognitively generated emotions, Emotional experience (cognitive awareness, physiological awareness and subjective feelings) and Body-mind interactions.

As alluded to above, a number of attempts have been made to model affective mechanisms although most only address the 'cognitively generated emotions'. Fundamental research was carried out by Ortony et al (1990) in their OCC model. This model is based upon an appraisal system where the world is divided into situations consisting of events, agents and objects. Emotions, then, arise from valenced (i.e. positive or negative) reactions to these situations

A further model of affect in cognition is Sloman's (1999) CogAff architecture which utilises a triple-layered approach consisting of a reactive layer, a deliberative layer and a self-monitory layer. However the CogAff architecture has, to date, had limited application in synthetic character design. Elliot's Affective Reasoner (AR) is based on the OCC model described previously where emotions are said to be "a byproduct of goal-driven behaviour, principled (or unprincipled) behaviour, simple preferences, and relationships with other agents" (Elliot et al., 1999). Elliot's work has been used in embodied agent design as discussed in a subsequent section.

2.2 Believability

In essence the creation of a believable character relies on the premise of there being a believable personality in the eyes of the beholder. Lester et al (1997) experimented with an animated agent 'Herman the Bug' which inhabits a learning environment. They noted that the use of a believable character can have a motivating effect on a student's interactions in a learning environment, the 'persona effect', something which inspired this research.

Reeves and Nass (1996) describe work on the Computers as Social Actors (CASA) project which aims to refute or assert the Media Equation hypothesis that people respond to mediated communications (i.e. television or computers) much the same way as face-to-face communications. If the assumption is correct then the vast literature on interpersonal communications, for instance personality traits, is relevant to the field of mediated communications.

Therefore based on the personality literature Reeves and Nass (1996) make predictions for mediated personalities. For example, they adjusted a computer 'personality' like its name, appearance of confidence and language to portray dominant and submissive personalities and found out that people respond best to personalities similar to their own.

Of the Big Five personality traits (McCrae & John, 1992) McCrae and Costa (1989) have identified two, extraversion and agreeableness as being most relevant to interpersonal interaction. In fact in the interpersonal circumplex theory of personality (Wiggins, 1979) the extraversion trait (also known as power, status or control) is said to range from dominance to submissiveness and the agreeableness trait (also known as affiliation or warmth) is said to range from warm to cold or agreeable to quarrelsome. This research assumes the extraversion and agreeableness traits as they are crucial in interpersonal interaction.

Reeves and Nass (1996, p.97) conclude that "*the creation of personality on a computer is not primarily an issue of artificial intelligence*". This is of concern in this research as complex Artificial Intelligence (AI) techniques are obviated in favour of more intuitive artistic, design-based, methods.

2.3 Embodiment

The key ideas of Damasio (1994) and Picard (1997) relating to emotional experience arising from embodiment have been mentioned. Also of influence to this research is the notion of embodiment and associated emergent properties of intelligence proposed by Brooks (1999). The following exemplars illustrate the approach.

Bates et al (1992) describe pioneering work undertaken as part of the 'Oz' project. Bates and his team are interested in designing "artistically interesting simulated worlds". They designed an architecture, Tok, consisting of various sub-components including an emotion and social relationships component, Em, where the overall goal is to produce believable characters in the same mould as Disney characters. Tok is illustrated by means of a simulated cat, Lyotard, who lives in a simulated world. Em can simulate such emotions as hope, fear, happiness, admiration, remorse and hate by using an OCC-like appraisal mechanism.

Rickel and Johnson (1999) describe a pedagogical agent, Steve, which inhabits a virtual reality training environment. Elliot et al (1999) describe an AR (described above) implementation of Steve where Steve can perform complex chains of affective reasoning to, for instance, express 'happiness' perhaps when a student reaches a correct answer in order to convey 'enthusiasm'. Elliot and Brzezinski (1998) also describe Elliot's AR agents which successfully utilise expressions and modulate speech to convey emotive states.

Cassell et al (2001) are interested in modes of communication which "come for free" such as NVBs but emphasise that these additional modes must be integrated with the communicative intent rather than being additive. Interestingly, Cassell et al have used a WoZ approach similar to this research (Barker, 2002) to compare user's reactions to agents with and without interactional behaviours finding that "users judged the version with interactional behaviours to be more collaborative and more cooperative" (Cassell et al., 2000, p.59).

In-keeping with the notion of design-based and model-based approaches to character design Andre and Rist (2001) distinguish between scripted and generated behaviours in their presentation agents. The former are "a temporally ordered sequence of actions" (Andre & Rist, 2001, p.53) including NVBs, facial expressions, utterances and movements whereas the latter are actions formulated on the basis of higher level rules and possibly plans. Andre et al make use of language and speech intonation to help portray a character's personality saying "the look and voice of a character are indeed important cues concerning it's personality and interest profile", (Andre et al., 2000, p.246). This strongly resonates with this research.

3 Designs On Life

This research specifically implemented an environment, ProSILA (Prototype Summary Intelligent Learning Assistant) which includes a browser pointing to the Physics VLE and two animated study companions that help students to write summaries in a separate summary window (see Figures 1, 3 and 4).

3.1 Philosophy of Personality: Affectations

The proposition is that behaviour-based affect, Picard's 'emotional behaviour' (Picard, 1997) is sufficient to portray the illusion of life. Barker and Pilkington (2001) discuss the seven affectations used to portray each of the two characters, the dominant Genie and the submissive Peedy, see Table 1. Additionally, each realisation of these affectations is described in terms of the four *subtle expressions* discussed below. For example, the Genie is portrayed as 'abrupt' through the use of terse language and Peedy as 'casual' through the use of colloquialisms.

Genie		Peedy		
affectation	**realisation**	**affectation**	**realisation**	**trait**
hasty (dominant)	less time waiting for user input	patient (forceless)	waits reasonable time for user input	D-S
sarcastic (disrespectful)	says "clever you" & applauds	encouraging (charitable)	says "ok", "well done", etc.	Q-A
stubborn (domineering)	7/10 chance he'll ignore 'user next' request	amenable (unaggressive)	always gives way to users turn	D-S
macho (domineering)	deep voice & muscular	wimpy (meek)	feathered, rounded 'cute' parrot !	D-S
scary (warmthless)	upward lighting & arms folded	friendly (kind)	'light' voice tones & asks rather than tells	C-W
abrupt (firm)	terse language	casual (unauthoritative)	uses colloquialisms	D-S
demanding (discourteous)	e.g. "I'm going next"	polite (well mannered)	e.g. "can I go next please"	Q-A

Table 1. Affectations of Genie and Peedy, their circumplex correlates and the corresponding trait (Wiggins, 1979) (D-S = dominant-submissive, Q-A = quarrelsome-agreeableness, C-W = cold-warm)

3.2 Animation and Dialogue

Barker (2002) describes some example 'moves' (episodes in a constrained interaction dialogue, utilising a state-based approach) for the Genie character. Each move is realised in terms of character animations together with appropriate dialogue. For example, the move of a 'no' response from the Genie would result in the Genie thrusting its hands out to the side whilst shaking its head. This would be accompanied by the exclamation "no way!". The overall intention, in this instance, is to create the effect of a rather emphatic, discourteous refusal. This kind of effect is achieved by utilising the aforementioned design-based approach, carefully manipulating the following subtle expressions coupled with an iterative test-then-further-design phase. All of the time this iterative process is gently coaxing the characters into life through the expression of the target affectations. Of course, it is necessary at some level to have an idea of the personality of the character so that this test-then-further-design approach converges on the overall notion of the characterisation albeit within the parameters of the affectations and their subtle expression realisations. For example, as Peedy is a more submissive and diminutive character he may be conveyed as whimsical by the use of an evolving humorous dialogue whereas Genie would be honed to appear more serious.

3.3 Subtle Expression in Artefacts

The subtle expressions used in the implementation of the agents in this research consist of carefully crafted variations of *language*, *voice*, *appearance* and *timing*. *Language* was modelled after that used by the target students, that is, informal and colloquial (see Figure 1). Additionally, to appear dominant, statements may be used or to appear submissive, questions may be used. *Voice* was carefully crafted to be in-keeping with the characterisation of the agents, for example the character Genie has a deep register to mark a 'macho' dominant character whilst Peedy has a high pitched register to reflect his whimsical submissive character. Figure 2 shows the use of the Microsoft Agent Scripting Helper (MASH)[1] to carefully assign an individual pitch to each word thus creating the desired inflection and tonal register.

Figure 1. Subtle Expressivity: *Language* (Peedy saying "Hey ! I'm called Peedy").

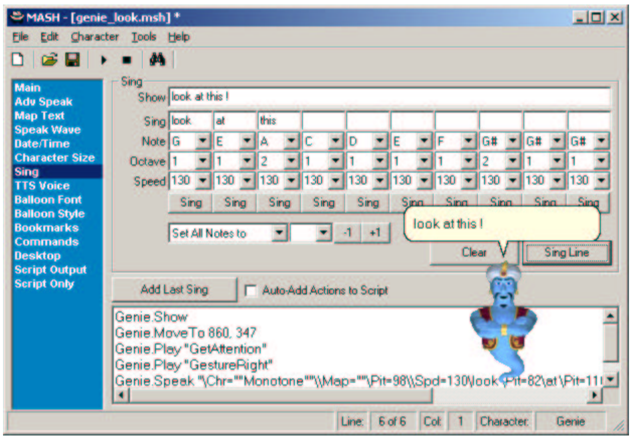

Figure 2. Subtle Expressivity: *Voice* (Genie 'singing' "Look at this !")

Additionally the macho Genie character was strengthened through the *appearance* of a moustachioed, muscular male whereas the whimsical Peedy character was emphasised through the choice of a Disney-type of parrot. Furthermore, the appearance of the character must match the communicative intent. For example, Robby the Robot will shrug his shoulders when making an uncertain statement, see Figure 3. Crucially, *timing* reinforced the impatient nature of the dominant genie character as it would soon interrupt whilst the submissive parrot would appear more patient in comparison. Timing was also very important in synchronising actions with dialog. For example, Figure 4 shows Genie gesturing towards an addition to the summary at the moment that it takes place.

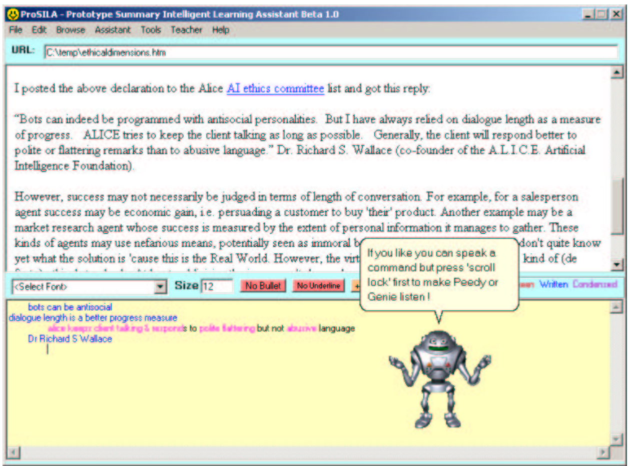

Figure 3. Subtle Expressivity: *Appearance* (Robby the Robot saying "If you like you can speak a command but press 'scroll lock' first to make Peedy or Genie listen !").

Figure 4. Subtle Expressivity: *Timing* (Genie saying "Look at this !").

4 ProSILA Architecture Overview

The final architecture uses a combination of a reactive and deliberative layer together with a world model (Barker & Pilkington, 2001) in the same vein as typical hybrid agent systems. The affectations can currently occur in the reactive layer, such as typical animation and dialog 'moves' outlined above but may also take place in the deliberative layer such as the varied responses dependant upon the relative importance of a student's contribution to the summary document. For example, Peedy will squawk and exclaim "Wow ! Please tell me why you did that !" then put his wing on his head inviting the student to explain why they have entered an unrecognised or unimportant phrase.

[1] http://www.bellcraft.com/mash/

Figure 5 illustrates a simplified architectural overview where the environment is the combined VLE and summary editor (as shown in Figure 1, 3 and 4). The sensors are the means by which ProSILA receives input from the environment such as a menu command, whereas the actuators could be ProSILA's 'moves'. The reactive layer also contains the dialog model and the deliberative layer contains simple summarisation rules and basic Natural Language Processing (NLP) capabilities. Finally, the world model contains the current summary document and an idealised 'target' summary.

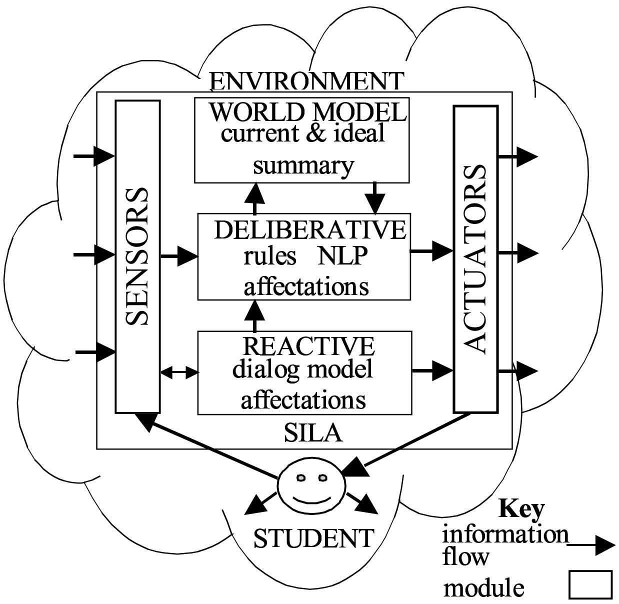

Figure 5. ProSILA Architecture.

Thus ProSILA will receive an input from the environment and/or student such as a student command for ProSILA to take the next turn. Commands presented to the student are adaptive in that only those relevant to the current state in the dialog model are displayed. This therefore allows the use of a simple constrained state-based approach to model the student-ProSILA interaction. If a state requires an addition to the summary by ProSILA then both the 'current summary' and 'ideal summary' are consulted to suggest the next best addition. This will be added to the summary as indented text which reflects a phrase's importance in the summary. If a state in the dialog model is reached which requires the student to add to the summary then the student will highlight the addition then command ProSILA to examine this addition. ProSILA then utilises keyword matching as a rudimentary form of NLP to recognise the student phrase and hence add it to the model of the 'current summary'. Additionally, ProSILA will examine phrases throughout the summary for common keywords and 'condense' or amalgamate them to create a more concise summary. Furthermore ProSILA can offer explanations like why a phrase has been added to a summary and provides further tools in the environment. These include a scratchpad for jotting down notes and more detailed help for the student on organising a summary, for example, how to tell if a phrase is important and hints on editing a final summary.

Finally, a newly added password-protected section of ProSILA can be used by instructors to author the mark-up which ProSILA requires for the 'ideal summary' thus allowing application in new course scenarios.

5 Validation Of Intentions

To ensure the effectiveness of ProSILA it is important to involve students in its development and the final evaluation.

5.1 Pilot Evaluation

A WoZ approach (Barker, 2002) was used in the initial design phase of the agents in order to finely hone factors such as dialog and particularly the type and amount of animation. In fact, one important result from this phase was that animation should be simplified and reduced so as not to distract from the summary construction task. The software was also piloted with colleagues. This proved invaluable as expert feedback was provided. As a result the spoken 'OK' user-command feedback was replaced with a head nod thus reducing the cognitive overload by employing more 'natural' behaviours.

5.2 Final Evaluation Method

The final evaluation employed a multimodal approach to data collection. Ten students (from CHALCS, local schools and participants from the WoZ) were interviewed before and after using the software and the screen was videoed during the *cooperative evaluation* (Dix et al., 1997) session for later analysis. The software also produced an annotated log of all interactions including times and details of any student or ProSILA commands, additions to the summary and any summarisation actions such as condensing of phrases. The log was analysed by classifying 16 differentiated student-assistant exchanges in terms of 4 categories. The four categories are a positive (or confirmatory) exchange, a negative (or disaffirming) exchange, an enquiry exchange (for example an explanation of a summary addition) and a miscellaneous category (for example a ProSILA condensation). Students were also asked to complete a Likert type scale for each of the 7 affectations, for example, 'hasty' equals –5 whereas 'patient' equals +5 with 0 representing no student perception of the affectation. These scores were then summed to obtain the overall student perception of affect. Observational notes were also taken by the experimenter. Additionally, the summaries were marked, using the same criteria, by two independent markers and the mean score derived. This multimodal approach to evaluation together with quantitative, e.g. statistical analysis of affect scales and dialogue exchange categories and qualitative, e.g. using a Grounded Theory (Strauss & Corbin, 1998) type of analysis of interview results, thus provided the necessary means to triangulate results which, when analysed, provided a rich picture of what actually ensued.

5.3 Final Evaluation Results

Table 2 shows some of the more relevant quantitative results of the final evaluation. It can be seen that most exchanges were positive, summary scores were quite high with a mean of 10.3 out of 16 (64%) and Peedy was perceived as having more positive affect than Genie as expected actually leading to him being chosen much more than Genie. Each student involved in the evaluation of ProSILA perceived affect in their interactions with the characters. Interestingly the degree of Peedy valenced affect perceived corresponded with the summarisation performance of the student (Barker, 2002), see Figure 6. That is, students with higher summary scores and those with lower summary scores perceived the most negatively valenced affect whilst students with an average summary score perceived the most positively valenced affect. One possibility then is to *adapt the affective behaviour of the assistants depending on a student's prior and subsequent performance*. This offers a more tractable solution than assessing a student's affective state to create a more consistent inter-student perception of character affect, in-keeping with design and pedagogical intentions. For example, the aim could be for a mean affect score of 31.5, see Figure 6.

Student	1	2	3	4	5	6	7	8
+ve	70	75	74	66	67	67	69	71
-ve	8	4	0	8	4	0	6	5
Enq	12	7	3	13	6	15	10	5
Sum	14	11.5	10.5	10	9.5	9.5	9.5	8
G aff	0	3	1	0	-16	-3	0	3
P aff	12	4	10	16	18	18	12	-3

Table 2. Evaluation results (+ve = positive exchange ; -ve = negative exchange ; Enq = Enquiry exchange: all as a percentage of total exchanges, Sum = mean summary score out of 16, G aff = Genie affect; P aff = Peedy affect: from +35 to –35).

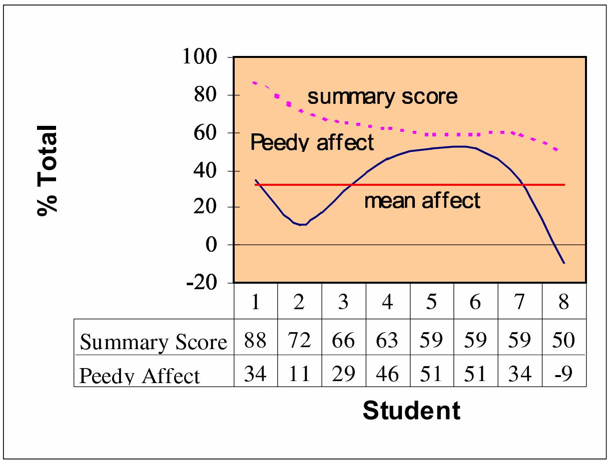

Figure 6. Correspondence of summary score and Peedy 'affect'.

Also of interest were the affective responses of *students* during their use of the software. These ranged from, e.g. negatively valenced reactions like anger to empathic situations such as returning a hand wave. One student said Peedy was "very helpful, almost like a kinship. You'd feel like he was really talking to you not just saying what he was supposed to say". On the other hand the student with the highest summary score became quite angry, saying to Peedy "alright, don't get smart" and "shut up man". This student unfortunately failed to complete an affectation scale so the result has been omitted from Table 1 and Figure 6 although it is thought that it would have been the most negatively valenced result. Also, one summary was lost due to a malfunction so these results have been discounted too. It was observed that some students did appear to be learning from the assistants as they would allow them to take the initial turns and add to the summary before feeling confident enough to attempt the task themselves. However, further analysis, including analysis of the pedagogical effectiveness of the characters is planned. Undoubtedly though, students did react affectively to the characters.

6 Future Work

Further work could be carried out to increase the interest-factor of the two assistants by using randomised choice of 'move' realisations. More fundamentally, it is hoped that the summarisation ability of the assistants can be enhanced by utilising rhetorical structure analysis software (Marcu, 2000). It is also desirable to increase the adaptivity of the two assistants, not just in terms of their affective qualities but, and perhaps more importantly, enabling them to learn from each other as to what are effective summarisation strategies as judged by students and teachers alike. This could be achieved by utilising a client-server or peer-to-peer architecture allowing logging and aggregating of student-agent interactions. For example, increasing an index value of an assistant's summary addition on receiving a 'well done' response from a student.

In terms of research one proposal is to test the *adaptation-performance hypothesis*. That is, "adapting agent affect to affect student affect based on student *prior* performance will affect student *subsequent* performance". This hypothesis is based on the results expressed herein as well as a 'contagion assumption' which states that student perception of agent affect leads to a corresponding student affective response. These experiments would ideally utilise typical control groups as well as performance pre and post tests together with student self-reporting and psychophysiological measurements.

The wider vision is to enable 'Social Computing' through provision of such socially responsive educational agents, possibly as representatives in mediated communications. For example, they could employ subtle expressions conveying enthusiasm, self-gratification and empathy. On a physical level these may be realised as gesticulation, a smile response to an affirmative comment or an adoption of an interlocutors posture and tone respectively. These may be equally as important in artificial student representatives and their facilitators. Furthermore, it would be necessary to investigate how these subtle expressions can be *captured* and/or modelled as well as represented.

This last point hints at a possible alternative to the modelling and design approaches. As Silberman (2003) states: "The standard way of simulating the world in CG is to build it from the inside out, by assembling forms out of polygons and applying computer-simulated textures and lighting. The ESC team took a radically different path, loading as much of the real world as possible into the computer first, building from the outside in. This approach, known as image-based rendering, is transforming the effects industry." There are lessons here to be learned by all those involved in creating realistic animated agents, from those in the film industry to computer game designers and even educationalists creating animated pedagogical agents.

7 Conclusion: Mind, Body And Soul

One fundamental tenet of this research is that it is not necessary to model underlying cognitive (particularly affective) functioning in order to create *impressions* of affective behaviour. Thus, it is proposed that by showing student affective responses to these agents without utilising a cognitive model, this belief can be confirmed. This has echoes of the classical cognitive versus behaviourist view of mind and, more pertinently, resonates with notions of 'strong' versus 'weak' AI. It may even be related to the dualistic dilemma of Descartes' followers in that it is possible to separate mind from body. It would seem though that mind and body are interdependent (Damasio, 1994). It may be that life, or consciousness, is created at their conjoining which, paradoxically, is sometimes put forward as an argument *for* Artificial Intelligence embodiment. Additionally, this consciousness may be socially situated (Vygotsky, 1978) in that societies of agents form a sentient organism from which intelligence 'emerges' (Johnson, 2001). Furthermore, we may in fact not yet have the language with which to express this phenomenon (Brooks, 2001). In other words discovering the crux of life forms part of others' ongoing research efforts. However, it is proposed that the *illusion* of life, particularly in animated agents, is less elusive.

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