THE RELATIONSHIP BETWEEN VISUAL ABSTRACTION AND THE EFFECTIVENESS OF A PEDAGOGICAL CHARACTER-AGENT

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Growth in Internet use and the market for online education[1] have created a demand for computer-based delivery of educational content. Associated with this demand has been experimentation in development of character-agents with the potential to deliver educational content (e.g., Marriott et al. 2001; *INTERFACE: Multimodal Analysis/Synthesis System for Human Interaction to Virtual and Augmented Environments* 2000; Information Societies Technology, IST, Programme 1999). Much of this development has concentrated on achieving realistic or lifelike agents, yet there is little research on the relationship between the way in which a character-agent is represented and its effectiveness as a communicator. This paper describes research designed to investigate the influence of one aspect of character-agent representation, the degree of visual abstraction, on the effectiveness of information transfer to a user.

The research is being conducted in three phases. The first phase consists of a review of the practitioner and research literature in order to identify those characteristics of a character-agent associated in the field with a 'good' agent. On the basis of this review, we propose a model of the relationship between character-agent characteristics, developer and designer criteria for good quality, and effectiveness of character-agents. In the second phase, practitioner interviews are being used to confirm and extend our understanding of the theories-in-use which influence the ways in which character-agents are being designed. In the third phase, field studies informed by the theories-in-use represented in the model, as confirmed or extended by the interviews, will test the relationship between the degree of visual abstraction of a character-agent and its effectiveness in delivery of information to university students. This (written) paper provides an overview of the characteristics which emerged from the literature review and our proposed model of the relationships between them and the effectiveness of information delivery, then presents the results of initial analyses of the interviews with practitioners and describes the design of the experiments to be conducted during the next few weeks. The conference presentation will include more complete presentation of the interview results and the results of the initial field study.

Research on representation of character-agents

A character-agent can be defined as a computer-based program that performs a particular function and is embodied or manifest audiovisually via a screen-based synthetically or artificially constructed character. The two elements of a character-agent (*agent* and *character*) reflect assumptions about the characteristics of a 'good' synthetic agent. A software *agent* includes the properties of being reactive, autonomous, goal-oriented, and temporally continuous (Franklin & Graesser 1996). A *character* has characteristics which include '. . . believable "personality" and emotional state' (p. 4). Research on the representation of character-agents emphasises users' personal response to these characteristics. It focuses on users' perceptions of the extent to which an agent has met the goals of believability and emotional range (Lester et al. 1997; Beard et al. 1999) rather than outcomes of use, such as the ability of the agent to deliver information effectively. While it is critical for the success of an informational agent that the agent actually deliver information effectively, there is surprisingly little research about the relationship between an agent's characteristics and its effectiveness.

Experts in human-computer interaction assume that the closer communication with a character-agent matches communication among humans, the better that communication will be. In the aspiration to create more natural communication processes in this field, developments such as the creation of anthropomorphised synthetic entities have been thought of as obvious and natural solutions (Shaw et. al. 1999). This may contribute to more human-like computer interaction for the user. 'We refer to such assignment of human attitudes, intentions, or motives to non-human entities as *ethopoeia*, the classical Greek word for such attributions.' (Nass et al. 1993, p.111). To create more natural communication it has become increasingly possible to enable the computer to simulate human communication processes especially with anthropomorphised character-agents faces, allowing us to more closely mimic the situation of human to human communication, a condition we are already well versed and adapted to:

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[1] The market for eLearning in higher education has been estimated to be worth almost USD750 million by 2004 (*NUA Internet Surveys* 2000).

. . . such programs would start with knowledge structures representing the concepts to be expressed and then translate each concept into spoken language and articulated facial and bodily movements (Kurzweil 1992, p. 412).

Human Computer Interaction (HCI) studies conducted by Stanford University researchers have investigated the theory that the computer and even more so its anthropomorphic projections (such as character-agents) are treated as social actors by their human users (Nass et al. 1994; Nass & Moon 2000). Human users were seen to apply rules and behaviors of social interaction and conventions towards computers exhibiting often quite minimal characteristically human cues such as voice and on screen facial representation (Nass et al. 1994).

On the other hand, the designers and developers of character-agents have been criticised for giving high priority to the conceptualisation of technical specifications, functionality and programming details (Ball et. al. 1997) with less regard to the communication quality of the agent. Even though the usefulness of some kind of audiovisual manifestation is acknowledged in this field, how a character-agent is embodied in practice is often an afterthought decided on the basis of the conventions of previous examples, popular or favourite trends, whim or what is available at the time.

Some designers and researchers have explicitly considered the particular audiovisual representation of a character and its effect along several dimensions, but there have been no empirical tests of the communicative effectiveness of different representations. However, how or why a particular representation may or may not be more effective than another in terms of information delivery is worthy of investigation. It is the contention of this research that character-agent visual representation influences the effectiveness of information delivery.

While no research has been done to define characteristics of character-agents associated with effective information delivery, research on users' emotional or affective response to character-agents has identified many factors to consider in the design of their audiovisual representation. These factors, when combined, form the embodiment of a character-agent. When investigating the effect of a specific factor or set of factors the other complementing factors should also be taken into account. Some examples of factors to consider when creating and evaluating an audiovisual representation are:

- Believability, a factor the Oz Project Group from Carnegie Mellon University describes as important for affective engagement 'As autonomous agents become richer, we believe it will become increasingly important for some of the agents to have believable and engaging personalities' (Loyall & Bates 1993).

- Personality as attributed to the mega-computer HAL in the movie Space Odyssey 2001 (*2001: A Space Odyssey* 1968, [video recording]) and as described by Nass et al. (1995) as an important factor for believable agents.

- Tone of voice and suitability to context such as the voice of cyberassistant character Mya, Motorola's voice-activated web browser, a 24 hour talking Internet service (Larsen 2000). Writer and associate creative director Pete Jones of the advertising firm McCann-Erickson said, "We wanted a voice that exuded some confidence and accountability, because Mya is someone who's going to deliver all this information," (Larsen 2000, p. 90).

Wilson (1997) discusses the difficulties in designing representations of character-agents: 'What would make a good character, and representation?' (Wilson 1997, p. 6). He outlines a selection of film animation principles such as appeal, staging, timing and realism and their potential application in the context of character-agent design. He also outlines a selection of non-propositional cues in human expression such as physical appearance, body movement and posture, facial expression, eye contact, intonation, word choice and grammar and proposition content of speech and considers whether this approach towards realism may create too high an expectation of the character-agent's abilities.

The various configurations of these variables have the potential for the creation of many possible audiovisual representations for a character-agent. Choosing an effective and appropriate character-agent representation for information delivery to a particular set of users is important. While the listed variables are believed to be factors that affect user response, we have no empirical evidence about which, if any, of these factors are also associated with effective information delivery.

In general, abstract representations are believed by designers to be more effective in conveying information because their lack of detail allows people to focus more on the information content. Writers on design believe:

> Unlike detailed realistic drawings, sketches help focus the mind on what is important, leaving out or vaguely hinting at other aspects. Sketches promote the participation of the viewer. People give more, and more relevant, comments when they are presented a sketch than when are given a detailed drawing. A realistic drawing or rendering looks too finished and draws attention to details rather then the conceptual whole (Stappers et al 2000).

This point of view seems inconsistent with attempts to make character-agents more life-like. It is possible, however, that response to anthropomorphised character-agents, and especially their faces, may differ from responses to sketches, based on evidence of human response to faces (Bruce et al. 1992; Hay & Young 1982). Gregory and his colleagues (1995) conducted studies on human response to faces at the physiological level. They demonstrated that humans are particularly receptive to faces. In terms of recognition they were more responsive to real faces than to abstracted line faces. Although less responsive to abstract line faces, they speculated that people spend longer studying them and may find them more interesting. A representation of a real person's face was recognised as the best likeness of the person but the participants responded more quickly in naming an exaggerated caricature of the persons face although the participants did perceive it as unreal (Gregory et al. 1995).

This suggests that an abstract face may introduce more 'noise' into the communication than a realistic one by encouraging a user to spend more time looking at the abstract character. On the other hand, more realistic character-agents may introduce other forms of noise associated with the user's curiosity about the personality of the character and over reading of unintended messages because of presentation complexity (Wilson 1997; McCloud. 1993).

Communication theory provides a framework within which to analyse and test these apparently contradictory predictions about the effectiveness of abstract and realistic visual representations of character-agents. Berlo (1960), drawing on the Shannon and Weaver (1948) communication model represented the components of communication as source, message, channel and receiver (Figure 1). Where source, message and receiver are constant, a channel with noise is less effective than one without noise (Bello 1953).

Figure 1. David Berlo's SMCR Model of Communication (Berlo 1960)

In this research, a character-agent is considered to be a channel through which a message may be communicated. The character-agent must be appropriate to the context of communication, the source, message and receiver. Character-agents that are inappropriately represented, placed in an unsuitable context, or mismatched to the target user group could result in distortion of meaning thus creating ineffective solutions, or even negative outcomes for the user (Quittner 1999).

Method

This section provides more detail about the three phases of the research which were summarized in the introduction to this paper.

In the first phase, a literature review was conducted to identify what are considered to be the qualities of a 'good' character-agent. Two sets of literature were examined: the academic literature, as a source of theory and empirically tested criteria; and the practitioner literature, to identify theories-in-action. The characteristics studied or described in the literature have been classified, and the detail of the proposed or tested relationship between each characteristic and user response to the agent has been recorded. The primary classifications are included in Table 1. The relationships noted in the literature have been classified as being associated with users' personal or emotional response (affect, or how the user feels about the agent and its use) or with the effectiveness of the agent in achieving its aims to either inform or entertain. The relationships between these elements of the theories-in-use have been mapped in a model which appears in Figure 1.

Designers and developers who are acknowledged by their peers as leaders in character-agent design and development are being interviewed in the second phase of the research. The interview questions are

designed to identify the characteristics these designers and developers associate with a good agent (i.e. the practitioners' theories-in-use). To date, eight interviews of around 45 minutes have been conducted, four with computer scientists developing a talking head for information delivery and four with practising multimedia designers and animators. These groups were selected in order to identify the views of the range of professionals working in this new field. (As this area is still relatively new, other fields such as film animation or social psychology that may be related are often referred to in the design of character-agent representation, Wilson, 1997.) While the first group is specifically developing informational agents, they have had little commercial experience. The second group has commercial experience in development of characters or agents, but less specific experience in development of informational character-agents. The aim is to conduct sufficient interviews to identify similarities and differences between the practising designers theories-in-action and those expressed in the literature. Based on the patterns which have emerged from the interviews analysed to date, we expect 8-10 interviews will be sufficient. Statements made in the interviews are being classified using the scheme which emerged from the literature review. Additional characteristics or relationships have been recorded in an extended table of theories-in-action. In addition to the characteristics and relationships mentioned in the interviews, the tone and emphasis of the interviewees has been used to identify potential differences in the concerns of the practitioners and writers in the field. The first two phases of the research have produced a set of heuristics for character-agent design which will provide a framework for the third phase.

In the third phase, a series of controlled experiments will be conducted, using the initial heuristics and the relationships between them. to test the hypothesis:

Abstract visual representations for character-agents are more effective for information delivery than realistic visual representations for character-agents.

They will further test if this is because abstract visual representations for character-agents have less noise than realistic visual representations for character-agents. Drawing on Berlo's (1960) SMCR model, the first experiment will hold the components of source, message and receiver constant. The channel, consisting of three different visual representations of a Talking Head, will be varied. A selection of three visual treatments of a character-agent will be chosen from the spectrum of iconic photorealistic (*realistic*) to abstracted schematic (*abstract*) representation (McCloud 1993). This will be in the form of three heads (hence the name Talking Head) in the forms illustrated in Figure 2: one detailed and realistic treatment (extreme left), one lesser detailed treatment, and one least detailed treatment (extreme right). Subsequent experiments will vary receiver characteristics such as familiarity with the Talking Head and gender, depending on the results of the first experiment.

Iconic Photorealistic|------------------------|Iconic Schematic|-------------------------|Abstracted Schematic

Figure 2. Illustration of the representations to be compared.

The experiments will test effectiveness along three dimensions associated with learning: recall (or retention) of the information delivered through the facilitation of the Talking Head, comparison of pieces of information, and application of learning (learning transfer) through judgement and problem solving in which the information is applied in a new domain (Moreno et al. 2000; Spool et al. 1997). Noise, and other potential explanations of differences in the effectives of the head (drawn from the literature review and practitioner interviews) will be measured by a post-test questionnaire. Verbal protocol analysis (Ericsson & Simon 1993) will be used to enrich understanding of user cognition and affective response while using the

agent. Data in relation to affective user response will also be gathered in the post-test questionnaire to allow exploration of relationships between effect and affect.

Where possible, the research will use existing measurement scales, but most items will be developed specifically for this study using a semantic differential which will contrast responses along each dimension (e.g., *I found the agent to be believable … not credible; interesting … boring*). Based on the Berlo model, communication variables other than the level of abstraction of the head will be controlled, focusing on a specific type of message, from a specific source, delivered to a specific group of users, in a specific context. The selected context is university education, and the type of message is educational instruction; the source is the university lecturer or content provider and the receiver is a student enrolled to learn the content of the educational messages conveyed via the medium (channel) of a character-agent.

The data that will enable a test of whether abstract visual representations for character-agents are more effective for information delivery than realistic visual representations for character-agents. It should further provide some explanation of the results in terms of communication theory and the theories-in-use of writers and practitioners.

Results to date

The characteristics identified by the literature review are listed in the first column of Table 1. The review of the research literature confirmed that there has been no research on the relationship between agent characterisation and the effectiveness of the agent for information delivery, although the effectiveness of pedagogical agents has been studied and compared with that of learning from text (Moreno et al., 2000). Most of the literature which refers to effectiveness assumes that effectiveness is an outcome of positive affective response to the agent (i.e., that the agent is likeable, realistic and engaging). Although there are few tests of this relationship, there may well be a link between affect and effect, at least in the field of education. Educators work to develop a learning environment which engages learners affectively in the belief that such an environment stimulates deeper learning and motivation to continue to learn (Woolfolk, 2002). The key characteristics and the potential relationships between them are illustrated in Figure 3.
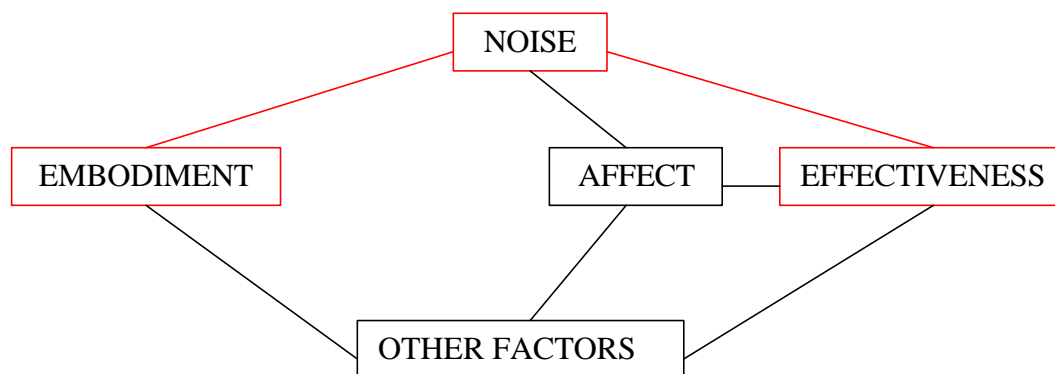

Figure 3. A model of the relationship between character-agent design elements and effectiveness in information delivery.

The path marked in red in Figure 3 represents the relationships of primary interest in this research: the effect of different levels of abstraction in the embodiment of a character-agent on the effectiveness of the head, and the extent to which this is mediated by noise or distraction from those characteristics of the head (*other factors*) which are designed to influence a user's affective response to the agent or its use. All of these factors will need to be measured in the experiments if the hypotheses that level of abstraction influences effectiveness by influencing distraction and noise is to be tested. In the experiments, embodiment will be represented by the different heads through their levels of abstraction.

The interviews analysed to date suggest that practitioners (agent developers) focus on a limited sub-set of the characteristics described in the literature. They are concerned with producing agents that meet their expectations (or their peers' expectations) of 'good' agents along those criteria, but make few explicit links between the qualities they seek to attain and the outcomes important to educators. Table 1 provides a summary of the concerns of six of the interviewees. (The conference presentation will include the full interview analysis.)

Table 1. Character-agent designer and developer criteria for agent quality

Category	Characteristics	Type of Agent	No. of interviewees
Personality	Persona, character, appropriate attitude	THI, ACE	5
Engagement	Value of uniqueness, the 'wow' factor	THI, ACE	5
Reliability	Meets technical requirements as a program or as defined by sponsor; fast and robust, does not break and therefore break the illusion	THI, ACE	4
Realism	Hair, face, anatomy, movement; resolution and detail such as texture, colour and graphic design; use of stereotypes	THI, ACE	4
Appropriateness	Appropriate relationship between elements such as role, voice, hair, personality; trueness to stereotype; appropriate to client's purpose and audience	THI, ACE	4
Believability	associated with realism	THI	3
Voice	Intonation & pitch, rate, range, expression of emotion, pronunciation, realism	THI	3
Anthropomorphism	Referred to as an entity and human or animal-like	THI, ACE	2
Intelligence	Gives the impression that it's 'smart'	THI	2
Behaviour		THI, ACE	2
Emotion		THI	3
Body language, non-verbal communication.	Includes gesture and expressions	THI, ACE	3
Cultural and social characteristics	A history and background, differences in perception associated with gender and ethnicity	THI, ACE	3
Integrity	synchronised speech, movement, voice	THI	1

Preliminary comparison of the emphasis of practitioners' remarks in interviews and the published literature suggest some differences between published theories and heuristic and practitioners' theories-in-action. These include the pressure to satisfy the client; we have provisionally classified this an extension of the notion of appropriateness, from appropriate to the role of the agent (such as teaching) to appropriate to the client's purpose such as presenting the training firm in a good light. The practitioners' remarks are more subjective with a stronger focus on their own emotional response and those of their peers than the literature which is more clinical in its representative of the criteria for recognition of a good agent. One interviewees' remarks illustrate the relationship between these characteristics:

> *Character is successful if sales and reviews are good (ultimately), as well as fellow designers like it, client likes it.* (Designer/character animator)

For some practitioners, personal preference may take precedence over the characteristics the literature assumes are associated with a good agent:

Real is good to show your skills off, but it isn't that interesting to look at. (Multimedia designer/character animator)

While the research literature tends to consider or analyse the effect of characteristics one by one, leaving implicit the relationship between the characteristics, the practitioners – like the designer-based practitioner literature (e.g. Wilson, 1997) – place a higher emphasis on the integrity of the technical elements of the agent, and of the relationship between the technical elements and the agent's purpose. The practitioners criticised the notion of stereotype but introduced the notion of story as a way to capture this type of integrity. Their comments include:

Less computery, more emotion, more human – we identify. Proper voice helps you understand – multiple communication channels. (Computer Science/Talking Head developer)

The story for this character is that he was a human but his DNA has been spliced with some insect DNA ...(Multimedia designer/character animator)

The results of the first experiment will be presented at the workshop. (Preliminary results, at least, should be available for inclusion in the paper submitted by 27 May.)

Conclusions

To date there has been little research on how the representation of a pedagogical agent is related to its effectiveness. Indeed, there is little concern among practitioners in particular, for the informational outcomes character-agent use. Instead, practitioners continue to focus on designing or developing 'good' agents as measured by the criteria internally generated by fellow designers and developers and the requirements of clients who commission agents. Researchers in the field have been more concerned with the outcomes of character-agent use, but their concerns focus more on responses associated with affect than with effect. The research described in this paper tests the fields' criteria for good character-agent design, and the underlying assumption that realistic and engaging agent-characters are likely to be effective communicators of information. Such research is timely given the growth in demand for and interest in computer-supported learning.

References

André, E., Rist, T. & Müller, J. 1997, 'WebPersona: A Life-Like Presentation Agent for the World-Wide Web', Presented at *Animated Interface Agents: Making them Intelligent (in conjunction with IJCAI–97)*, Nagoya, Japan.

Ball, G., Ling, D., Kurlander, D., Miller, J., Pugh, D., Skelly, T., Stankosky, A., Thiel, D., Van Dantzich, M. & Wax, T., 1997, 'Lifelike Computer Characters: the Persona project at Microsoft Research', *Persona @ Microsoft Research*, [Online], Available: http://www.research.microsoft.com/research/ui/persona/chapter/persona.htm [2001, February 13].

Beard, S., Crossman, B., Cechner, P. & Marriott, A. 1999, 'FAQBot', in *Proceedings of Pan Sydney Area Workshop on Visual Information Processing November 10 1999*, University of Sydney, Australia.

Bello, F. 1953, *The Information Theory, in Readings in Management Information Systems*, eds G. B. Davis & G. C. Everest, McGraw-Hill Book Company, New York, pp. 23-32.

Berlo, D. K. 1960, *The Process of Communication*, Holt, Rinehart and Winston, Inc, New York.

Bruce, V., Cowey, A., Ellis, A. W. & Perrett, D. L. 1992, *Processing the Facial Image*. Oxford, UK, Clarendon Press.

Ericsson, K. A. & Simon, H. A. 1993, *Protocol Analysis: Verbal Reports as Data Revised Edition*, The MIT Press, Cambridge Massachusetts.

Franklin, S. & Graesser, A. 1996, 'Is it an Agent, or just a Program?: A Taxonomy for Autonomous Agents', in *Proceedings of the Third International Workshop on Agent Theories, Architectures, and Languages*, Springer-Verlag, [Online], Available: http://www.msci.memphis.edu/~franklin/AgentProg.html [2001, February 13].

Gregory, R., Harris, J., Heard, P. & Rose, D. (eds) 1995, *The Artful Eye*, Oxford University Press, Oxford.

Hay, D.C., Young, A.W. 1982, 'The human face', in *Normality and Patholgy in Cognitive Function*, Ellis, A.W. ed., London, Academic Press, pp. 173-202.

Information Societies Technology (IST) Programme 1999, *Annex 1 – "Description of Work"*, INTERFACE: Multimodal Analysis/Synthesis System for Human Interaction to Virtual and Augmented Environments, Project Number IST-1999-No. 10036.

INTERFACE: Multimodal Analysis/Synthesis System for Human Interaction to Virtual and Augmented Environments 2000, [Online], Available: http://www.ist-interface.org [2001, June 11].

Kurzweil, R. 1992, *The Age of Intelligent Machines*, MIT Press, Massachusetts.

Larsen, E. 2000, 'Mya Way', *I.D. Magazine*, Special Robots Issue, October, pp. 88-91.

Lester, J. C., Converse, S. A., Kahler, S. E., Barlow, S. T., Stone, B. A., & Bhogal, R. S. 1997, 'The Persona: Effect: Affective Impact of Animated Pedagogical Agents, in *Conference Proceedings on Human Factors in Computing Systems*, pp. 359 – 366.

Loyall, A.B. & Bates, J 1993, 'Real-time Control of Animated Broad Agents'*,* in *Proceedings of Fifteenth Annual Conference of the Cognitive Science Society*, Boulder, CO., [Online], Available: http://www.cs.cmu.edu/Groups/oz/papers.html [1999, March 7].

Marriott, A., Beard, S., Haddad, H., Pockaj, R., Stallo, J., Huynh, Q. & Tschirren, B. 2001, 'The Face of the Future', *Journal of Research and Practice in Information Technology*, vol. 32, no. 3/4, August/November, pp. 231-245.

McCloud, S. 1993, *Understanding Comics: The Invisible Art*, Kitchen Sink Press Inc., Northhampton, MA.

Moreno, R., Mayer, R. E. & Lester, J. C. 2000, 'Life-Like Pedagogical Agents in Constructivist Multimedia Environments: Cognitive Consequences of their Interaction', in *Conference Proceedings of the World Conference on Educational Multimedia Hypermedia, and Telecommunications (ED-MEDIA)*, pp. 741-746, Montreal, Canada.

Nass, C., Moon, Y., Fogg, B. J., Reeves, B. & Dryer, C 1995, 'Can Computer Personalities Be Human Personalities?', Short Paper in *Conference companion on Human factors in computing systems CHI '95,* p.228 – 229, Denver, Colorado, USA.

Nass, C., Steuer, J., Tauber, E. & Reeder, H. 1993, 'Anthropomorphism, Agency, & Ethopoeia: Computers as Social Actors', *INTERACT '93 and CHI '93 conference companion on Human factors in computing systems*, pp. 111 – 112, Amsterdam, Netherlands.

Nass, C., Steuer, J. and Tauber E. 1994, 'Computers are Social Actors' in *Conference proceedings on Human factors in computing systems: "celebrating interdependence" CHI '94*, pp. 72-78, Boston, Massachusetts, USA.

Nass, C. & Moon, Y. 2000, 'Machines and Mindlessness: Social Responses to Computers', Journal of Social Issues, vol. 56, issue 1, p. 81-103.

NUA Internet Surveys 2000, [Online], Available: http://www.nua.com/surveys [2001, May 18].

Quittner, J. 1999, 'Are Video Games Really So Bad?', *Time*, May, pp. 50-56.

Shannon, C. E. 1948, *A Mathematical Theory of Communication* (Based on original Bell System Technical Journal version), [Online], (1998, February 2 – last update) Available: http://cm.bell-labs.com/cm/ms/what/shannonday/paper.html [2001, May 11].

Shaw, E., Johnson, W. L., Ganeshan, R. 1999, 'Pedagogical Agents on the Web' in *Proceedings of the third annual conference on Autonomous Agents99*, pp. 283 – 290, Seattle, WA, USA.

2001: A Space Odyssey [video recording] 1968, Metro Goldwyn Mayer Inc., Producer Stanley Kubrick.

Spool, J., Scanlon, T., Schroeder, W., Snyder, C., DeAngelo, T. 1998, *Website Usability: A Designer's Guide*, Morgan Kaufmann Publishers, San Francisco.

Stappers, P., Keller, I. & Hoeben, A. 2000, 'Aesthetics, interaction, and usability in 'sketchy' design tools', *Exchange Online Journal*, issue 1, December, [Online], Available: http://www.media.uwe.ac.uk /exchange_online/exch1_article4.php3 [2001, March 5].

Wilson, M. 1997, 'Metaphor to Personality: the role of animation in intelligent interface agents', Presented at *Animated Interface Agents: Making them Intelligent (in conjunction with IJCAI–97)*, Nagoya, Japan.

Woolfolk, A. 2002. *Educational Psychology*, 8th ed. Allyn and Bacon, Boston.