Contextually Relevant Pedagogical Agents: Visual Appearance, Stereotypes, and First Impressions and their Impact on Learning

Dr. George Veletsianos
University of Texas at Austin
Instructional Technology

Veletsianos, G. (2010). Contextually relevant pedagogical agents: Visual appearance, stereotypes, and first impressions and their impact on learning. *Computers & Education, 55*(2), 576-585.

Abstract

Humans draw on their stereotypic beliefs to make assumptions about others. Even though prior research has shown that individuals respond socially to media, there is little evidence with regards to learners stereotyping and categorizing pedagogical agents. This study investigated whether learners stereotype a pedagogical agent as being knowledgeable or not knowledgeable and how this acuity influenced learning. Participants were assigned to four experimental conditions differing by agent (scientist or artist) and tutorial type (nanotechnology or punk rock). Quantitative analyses indicated that agents were stereotyped depending on their image and the academic domain under which they functioned. Regardless of tutorial, participants assigned to the artist agent recalled more information than participants assigned to the scientist agent. Learning differences between the groups varied according to whether agent appearance fit the content area under investigation. Qualitative results indicated learner's stereotypic expectations as well as their unwillingness to draw conclusions based on visual appearance.

Keywords: pedagogical agents, virtual characters, stereotypes, visual appearance, contextual relevance.

1. Introduction

Virtual characters have been gaining influence in education; they have been examined as tools to enhance teaching and learning processes (Gulz, 2004, Veletsianos & Miller, 2008), given a physical image, portrayed as having a lifelike form (Gulz & Haake, 2006), and utilized within real-world instructional environments. More recently, virtual characters have become the standard rather than the exception: Educational institutions are scrambling to establish learning spaces in virtual worlds (Jennings and Collins, 2008) within which users have no option but to represent themselves as digital characters. These developments raise a number of questions regarding the use of virtual characters in electronic learning environments: How should virtual characters look? What impact, if any, does their external representation have? What is the role of visual aesthetics in the design of virtual characters? Does virtual character appearance influence learning, interaction, and learner perceptions?

The visual and aesthetic properties of virtual characters may influence variables of interest to researchers and practitioners within numerous domains. For example, children may be motivated to interact more frequently with characters portrayed as playful animals versus professional adults. On the other hand, children may perceive virtual characters portrayed as professional adults as model figures and be motivated to engage in higher level interactions with them (Bandura, 1977). These hypotheses are closely linked to ideas of first impressions, activation and application of stereotypes, and domain-specific virtual characters. First impressions frequently influence and guide subsequent interactions in real life (Ritts, Patterson, and Tubbs, 1992), while stereotypes are mental schemata intended to reduce information overload and enable humans to make quick judgments based only on a small set of attributes

(Devine, 1989). Previous work by Reeves and Nass (1996) seems to suggest that first impressions and stereotyping behavior transfer to human-agent interactions, thus having social and pedagogical implications.

In this paper, I explore these issues by asking whether (a) learners form impressions and apply stereotypes based on agents' visual appearance, and (b) agent visual appearance interacts with the content area in which agents function to influence learning. I proceed by reviewing prior literature, investigating the relationship between agent-learner interactions and the application of stereotypes, and presenting this study's research questions. Next, I explain the method used to study this topic, present my results, and conclude by discussing implications and limitations of this study.

2. Literature Review

Pedagogical agents are static or animated anthropomorphic interfaces employed in electronic learning environments to serve various instructional goals. Pedagogical agents are often given lifelike characteristics, such as emotion, reactivity, and speech (Rickel & Johnson, 2000), presented in human form, or portrayed within a fantasy realm as talking animals (Louwerse, et al, 2005), cartoons (Mayer, Dow, & Mayer, 2003), or bugs (Lester et al, 1997).

In an investigation of the virtual character literature, Dehn and van Mulken (2000) call for a fine-grained perspective on pedagogical agent integration. Specifically, they state that,

> The simple question as to whether an animated interface agent improves human-computer interaction does not appear to be the appropriate question to ask. Rather the question to ask is: *what kind of animated agent used, in what kind of domain influences what aspects of the user's attitudes or performance?*" (p. 19).

In relation to this recommendation, it appears that researchers are failing to examine one important dimension of pedagogical agent usage: agent visual appearance, which an issue that is at the forefront of learner-agent interactions. Students' learning, performance, engagement, and enjoyment when working with agents may be influenced by the way agents look. Gulz and Haake (2006) and Veletsianos (2007) support this claim by noting that the visual and aesthetic properties of pedagogical agents are an important design element that has been neglected in previous work. Arguably, the first item students notice when presented with a pedagogical agent is its obvious visible characteristics: gender, facial expressions, ethnicity, hairstyle, hair color, and clothing (Branham, 2001). These characteristics form the basis of first impressions and as such may activate stereotypes and expectations of agent usefulness, credibility, and intelligence. Taking this hypothesis a step further, an agent's visual appearance may interact with the content area under which the agent functions rendering the agent's visual appearance contextually relevant or irrelevant. For example, a pedagogical agent tutoring students on pre-school creative play practices may be expected to be visually different and conform to different standards than one teaching nuclear physics, gender studies, mechanical engineering, or history. Contextual relevance, the conformity of an agent's visual characteristics to the content area under which the agent purports to function (Veletsianos, 2007), therefore, may be an important element to be considered when designing and implementing pedagogical agents; especially due to the fact that it is an overlooked facet of agent design. Agent appearance convers non-verbal messages to learners influencing learner perceptions and the way learners interact with agents (Haake & Gulz, 2008; Plant et al., 2009; Rosenberg-Kima et al., 2008). Agent contextual relevance may activate stereotypes and agent knowledge/intelligence expectations in user minds, and this knowledge mapping may influence learning. Perceptions of competence (or incompetence)

derived from agent image may influence learners' attention and perceptions of agents' relevance, degree of seriousness, and authenticity, and thereby learning. More specifically, contextual irrelevance is expected to disrupt learning, leading to lower retention rates. The reason for this can be traced to Cognitive Load Theory (Sweller, 1994): A contextually irrelevant pedagogical agent increases extraneous cognitive load because learners have to attend to more than one cognitive schema. Contextual irrelevance would therefore hinder learning because of the strains it would impose on working memory limits.

Even though Moreno, Mayer, Spires, and Lester (2001) and Gulz and Haake (2006, 2009) called on the research community to investigate the role of agents' visual presence in multimedia learning environments, the impact of contextually relevant pedagogical agents has not yet been examined and visual appearance seems to be disregarded in a number of studies: For example, sorcerers have been employed to teach economics (Craig, Cholson, & Driscoll, 2002) and cartoon-like characters have been depicted as physics experts (Mayer, Dow, & Mayer, 2003) without consideration of the impact of contextual visual representations.

2.1 Media as humans: The media equation

Extensive experimental evidence by Reeves and Nass (1996) showed that humans treat computers, and media in general, in a social manner. By replicating experiments designed to examine social interactions amongst humans and applying them to interactions between humans and media, Reeves and Nass presented the *media equation* positing that users ascribe social rules to their interactions with media. For example, humans rate computers more favorably when they are "polite" even though computers lack the ability to be polite. Equally important, it appears that regardless of age, expertise with media, and media design, users tend to apply social rules to

their interactions with media (Alvarez-Torres, Mishra, & Zhao, 2001; Nass, Moon, & Carney, 1999).

2.2 The media equation: Implications for pedagogical agents

If humans apply social rules to media, it follows that when interactions with media are mediated by virtual characters exhibiting lifelike characteristics, anthropomorphous characters would also be subject to social rules. The evidence presented by Reeves and Nass (1996) is extended to the pedagogical agent literature by phenomenological evidence from Veletsianos & Miller (2008) who support the notion that learners perceive their interactions with pedagogical agents as being fundamentally real and natural.

When humans interact with humans, they use a number of non-verbal cues to make assumptions about others (Epleya & Krugerb, 2005; Gulz & Haake, 2006). Non-verbal cues come from any visible characteristic or object such as hairstyle, hair color, presence/absence of glasses, jewelry, clothing, ethnicity, gender, or voice inflection. The totality of non-verbal cues allows individuals to form impressions about others (Bonito, Burgoon, & Bengtsson, 1999) and draw on their stereotypic beliefs as an information source to make assumptions about others (Devine, 1989; Hamilton & Sherman, 1996; Macrae, Milne & Bodenhausen, 1994).

Stereotypes are defined as beliefs about the characteristics of groups of individuals (e.g., women are bad drivers, men do not ask for directions, Japanese are hardworking, Americans are individualistic etc.) and stereotyping is the application of those stereotypes when interacting with individuals from a particular social/ethnic group. Stereotypes are stored as schemata, often considered as types of cognitive neural networks, and their activation may be automatic and instantaneous (Devine, 1989). As stereotypes, pre-conceptions, and first impressions may lead

individuals to form expectations about others (Epleya & Krugerb, 2005), the media equation posits that the same set of cognitive functions may lead individuals to form expectations about pedagogical agents. For example, Norman (1997) argued that individuals may have increased expectations from agents because they may be presented in human form. Anthropomorphism seems to convey the impression of agents being intelligent and competent: A pedagogical agent portrayed as a historical figure of well-known intellect (e.g., Einstein) may convey a sense of competence and aptitude.

The implications of the empirical evidence presented in the previous paragraphs can be summarized as follows: (a) pedagogical agents will be subject to human interaction rules because humans treat media as if they are human, (b) when interacting with others, observable non-verbal cues enable individuals to form stereotypes, pre-conceptions, first impressions, and expectations about others, and such beliefs can be used as an information source to make assumptions and draw conclusions about others, and (c) stereotypes, pre-conceptions, first impressions, and expectations about others may influence perceptions and behavior. Because pedagogical agents will be treated in a social manner, and due to the fact that learners draw on their limited information sources to make assumptions about others, it is likely that pedagogical agents will be categorized and stereotyped. Categorization and stereotyping may in turn influence learner behavior and perceptions of pedagogical agents.

2.3 Stereotypes, first impressions, expectations, and agent images

Even though my investigation of previous literature showed that no research examined the interaction between agent image and content area (contextual relevance) with regards to stereotypes, a limited set of studies explored related facets of pedagogical agent image and

stereotyping. The following section examines theoretical claims and empirical evidence on how the external representation of pedagogical agents may influence how learners interact with them.

Previous research has shown that learners apply stereotypes to *computers* even when a pedagogical agent is not present. In accordance with the media equation, the presence of an anthropomorphic artifact is not a prerequisite for humans to apply social interaction rules to media (Dehn & van Mulken, 2000). For example, Alvarez-Torres, Mishra, and Zhao (2001) examined stereotypes with respect to a "native" vs. "non-native" multimedia computer tutorial. The "native" software group was presented with a tutorial purported to be developed in the USA, and introduced by a native voice encompassing a typical US name (Susan). The "non-native" software group was presented with a tutorial purported to be developed in Mexico, and introduced by a non-native voice bearing a non-American name (Carmen). The researchers found that participants assigned to the "native" software group recalled more information than those assigned to the "non-native" software group. Since previous research has shown that learners consider native speakers to be experts on the language under consideration, Alvarez-Torres, Mishra, and Zhao noted the result may have been due to participants paying more attention to the native voice.

Following the media equation line of research, Nass, Moon, and Green (1997) found that participants applied gender stereotypes to computers even though the only suggestion of gender was vocal cues. Moreno et al. (2002) extended the research on gender stereotypes to pedagogical agents by examining whether participants' stereotypic expectations regarding agent gender and ethnicity affected pedagogical efficacy. They found significant interactions between agent gender and pedagogical efficacy while agent ethnicity had no influence on learning. Results

indicated that participants applied social stereotypes based on gender and learned more from male agents.

Rosenberg-Kima et al (2008) have used pedagogical agents as a form of persuasive technology in an attempt to change female students' perceptions. In this study, pedagogical agents delivered persuasive messages to women to enhance their self-efficacy and self-esteem regarding mathematics, science, and engineering. Results indicated that participants were influenced by both young, "cool" agents (similarity hypothesis) and by older, "un-cool" agents (expert hypothesis). Even though agents were stereotyped, it seems that the activation and application of stereotypic expectations may not always work in a negative manner. For instance, agents who fulfill learners' stereotypic expectations may positively influence perceptions because they appear to be experts in the academic domain under investigation. Conversely, agents that do *not* fulfill learners' stereotypic expectations (e.g., in this case, female engineers) may also positively influence perceptions because learners may pay more attention and interact more with agents who are similar to them. This idea is called the Similarity-Attraction Hypothesis (SAH) and in the context of agent research poses that individuals are attracted to agents who appear to be similar to them. Even though similarity-attraction effects have been identified in human-human interactions, Moreno and Flowerday (2006) provide only limited support for the SAH in agent-learner interactions. Specifically, the researchers hypothesized that learners would be more likely to choose to learn with same rather than different gender/ethnicity agents, and that learners who learn with same gender/ethnicity agents would score higher on learning and affective measures than students who learn with different gender/ethnicity agents. Results only revealed support for students of color choosing to learn with same ethnicity agents.

Related to the SAH is the idea that physical attractiveness influences expectations, judgments, and impressions. For example, a large body of research has shown that attractive students receive more favorable judgments from their teachers as compared to their less attractive peers (Ritts, Patterson, & Tubbs, 1992). Extensive literature searches have not revealed any research attempting to replicate such experiments in the pedagogical agent domain. Likewise, virtual character researchers in general and pedagogical agent researchers in particular, have shown negligible interest in how users' first impressions of characters may influence variables of interest. Inferences about other peoples' traits (e.g., attractiveness, trustworthiness, competence) derived from unfamiliar faces have been shown to occur rapidly, (as fast as 100 milliseconds) while longer exposures to faces appear to have minimal influence on those inferences (Willis & Todorov, 2006). Gladwell (2005) describes this phenomenon as "the ability of our unconscious to find patterns in situations and people based on very narrow 'slices' of experience." These results provide support for the popular expression that "first impressions are lasting" and have broad implications for the design and development of anthropomorphic interfaces. The visual appearance of virtual characters and pedagogical agents should not be taken lightly. Learners are likely to form lasting first impressions based on a handful of visual social cues and such impressions may influence behavior and user perceptions of agent characteristics.

2.4. Research questions

Visual appearance may influence agent perceptions. Perceptions of competence or incompetence derived from agent image may influence learners' attention and perceptions of agents' relevance,

degree of seriousness, and authenticity, and thereby learning. To examine these ideas, I pose and answer the following questions:

- Do learners form first impressions and stereotype agents in terms of perceived agent competence?
- Does the influence of stereotypes depend on the subject matter under consideration? In other words, do learners who interact with contextually relevant pedagogical agents learn more or less and rate the agents differently than learners who interact with contextually irrelevant pedagogical agents?

It is hypothesized that learners will (a) form impressions about agents based on their visual appearance, and (b) stereotype pedagogical agents. Additionally, it is expected that contextual irrelevance will disrupt learning, leading to lower retention rates. At the same time learners are expected to learn more from contextually relevant pedagogical agents whose images may convey a sense of domain expertise.

3. Method

3.1 Participants

One hundred and thirteen individuals were invited to participate in this study. Ninety-four participants completed the pre- and post-test survey. Of the 94 students who participated, 79 were females and 15 were males. Their average age was 22.75 years (SD = 4.03). Participants were enrolled in three elementary/special education technology courses and one early childhood education technology course. The courses were content and cohort-specific and part of a post-baccalaureate masters program in education.

3.2. Materials

The materials used in this study consisted of two tutorials, two audio recordings, two pedagogical agents, a pre- and post-test survey, and two scoring rubrics.

3.2.1 Tutorials

Two introductory tutorials (one on nanotechnology and one on punk rock) were devised for this study. The tutorials were authored and edited for uniformity in terms of complexity, length, clarity, and tone. The tutorials were also edited for word choice such that, when spoken, words would be clear and concise. The topics of nanotechnology and punk rock were chosen because (a) the two respective academic domains (science/engineering versus music) were perceived to be significantly different from each other, and (b) participants' prior knowledge of, and exposure to, these two domains was expected to be uniform and limited. These assumptions were assessed and results are presented below.

3.2.2 Audio recordings

Audio recordings of the two tutorials were created. The recordings were similar in pace, speech, and language style. The nanotechnology audio file lasted for 5 minutes and 7 seconds and the punk rock audio file lasted for 5 minutes and 4 seconds.

3.2.3 Pedagogical agents

Two pedagogical agents each delivering the two tutorials described above were designed. The two agents were derived from the same agent image and were identical in face shape, facial

expressions, body image, clothing, dimensions, voice, and animation. They differed in hair style and color, and style of facial hair and color. One agent also wore a necklace. Using lip synchronization software the agents were able to present the audio files described above in spoken voice. Results from a formative study indicated that the two pedagogical agents were sufficiently different. Henceforth, the first agent will be called a "scientist" and the second will be called an "artist" (Figure 1).

Figure 1. Scientist and artist pedagogical agents

3.2.4 Pre-test survey

A pre-test survey was used to collect demographic information about participants, evaluate each group's prior knowledge about nanotechnology/punk rock and science/music, elicit first impression ratings regarding perceived agent knowledge, and gather qualitative data on why participants rated the agents as they did.

3.2.5 Post-test survey

The post-test survey consisted of an open-response recall task asking learners to write all that they could remember from the pedagogical agent presentation.

3.2.6 Scoring rubrics

Scoring rubrics, one for the nanotechnology tutorial and one for the punk rock tutorial, were used to evaluate student responses to the open recall tasks posed in the post-test survey. The scoring rubric was initially piloted with a second rater and it was found that the scoring criteria were too broad and open to interpretation. Therefore, a tighter scoring paradigm was devised and used (inter-rater consistency is delineated below).

3.3. Experimental design and treatments

The study employed a 2x2 between subjects factorial design with four independent samples. The two experimental factors were Pedagogical Agent depiction (i.e. Scientist [PA1] or Artist [PA2]), and Tutorial type (i.e. nanotechnology [T1] or punk rock [T2]). Visually, the two conditions can be represented as a 2x2 matrix:

Table 1

Study design

Agent Depiction	Tutorial Type	
	Nanotechnology	Punk Rock
Scientist	N=21	N=22
Artist	N=24	N=27

3.4. Dependent measures

3.4.1 Stereotypical expectations and first impressions

In the pre-test survey participants were asked to report the extent to which they agreed with the statement "The agent is knowledgeable." The only information provided to participants was the image of the pedagogical agent and the type of tutorial to be presented (nanotechnology or punk rock). Responses from this question were used as a proxy for participants' first impressions and stereotypical expectations of pedagogical agents' expected knowledge.

3.4.2 Learning

Learning was assessed as recall of factual information. The researcher and a second rater used the scoring rubrics to independently and blindly score participant responses to the open recall tasks posed in the post-test survey. Out of 94 ratings, 17 discrepancies were noted. All discrepancies differed by plus/minus 1 point. A scatter plot of the two ratings indicated a linear relationship, enabling the use of the Pearson Product-Moment Correlation coefficient to examine inter-rater reliability. Pearson's correlation between the ratings reported by the first researcher ($M = 5.5$, $SD = 4.86$) and the second researcher ($M = 5.6$, $SD = 4.88$) was $r(92) = 0.99$, significant at the .01 level. Thereafter, the two raters discussed the 17 discriminate cases, explained their reasoning of why the ratings differed, and reached a consensus on each discriminate case.

3.5. Data analysis

Between subjects Multivariate Analysis of Covariance (MANCOVA) procedures were used to examine whether (a) learners apply stereotypes to pedagogical agents, and (b) learning outcomes are influenced by pedagogical agent representations consistent with the academic domain under investigation. For all quantitative analyses, alpha was set at 5%. Significant MANCOVA effects were examined further with univariate ANOVA procedures, and investigation of the mean and standard deviations of the dependent variables. Qualitative data were used to further explain the results.

3.6. Procedure

The researcher visited one course section at a time and invited students to participate in a study examining the impact of pedagogical agents on student perceptions and learning, *without informing* participants that agent appearance in connection to content area are the variables of interest. Participation was strictly voluntary and involved no academic or monetary compensation. Students who chose to participate in the study completed a consent form and were given 5 minutes to complete the pre-test survey. Once the 5 minutes were over, participants were asked to view a tutorial presented by a pedagogical agent. Each class was randomly assigned to one of four experimental conditions. The first two conditions involved a nanotechnology tutorial presented by the scientist agent (PA1 x T1) or the artist agent (PA2 x T1). The last two conditions involved a tutorial on punk rock delivered by the same scientist (PA1 x T2) or artist agent (PA2 x T2). At the end of the tutorial, participants were given 10 minutes to complete the post-test survey. At the end of the 10 minutes, participants were debriefed.

3.7. Prior Knowledge

Participants in a particular class could differ in skills and abilities from a second class assigned to the same tutorial with a different agent. For example, regardless of the tutorial, participants in condition PA1 x T1 could have exhibited greater knowledge of nanotechnology than participants in condition PA2 x T1. To account for prior knowledge differences between the groups, participants were asked to rate their nanotechnology/punk rock and science/music knowledge. These two variables were used as covariates in the MANCOVA analysis.

4. Results

Significant differences were found on the agent factor, Wilk's Λ=.77, F(2, 85) = 12.56, p<.001; tutorial factor, Wilk's Λ =.68, F(2, 85) = 19.93, p<.001; and the agent-tutorial interaction, Wilk's Λ =.82, F(2, 85) = 9.63, p<.001on the dependent measures. Table 2 presents the means, standard deviations, and sample sizes for each of the agent and tutorial treatment groups.

Table 2

Means, Standard Deviations, and Sample Sizes

Dependent Variable	Agent Type	Tutorial Type	n	Mean	SD
Learning	Artist	Nanotechnology	24	3.59	2.91
		Punk rock	22	10.55	4.67

		Total	46	7.07	5.21
	Scientist	Nanotechnology	21	2.48	1.81
		Punk rock	27	5.67	4.71
		Total	48	4.27	4.03
	Total	Nanotechnology	45	3.05	2.47
		Punk rock	49	7.86	5.25
		Total	94	5.61	4.81
First impressions	Artist	Nanotechnology	24	3.36	0.58
		Punk rock	22	3.91	0.61
		Total	46	3.64	0.65
	Scientist	Nanotechnology	21	3.38	0.74
		Punk rock	27	2.96	0.76
		Total	48	3.15	0.77
	Total	Nanotechnology	45	3.37	0.66
		Punk rock	49	3.39	0.84
		Total	94	3.38	0.75

4.1 Prior knowledge

No significant main or interaction effects were noted between the experimental groups with regards to learners' prior knowledge. This result indicates that participants' self-reported knowledge of nanotechnology, punk rock, science, and music, was largely uniform, indicating that any differences in learning are not attributable to learners' prior knowledge.

4.2. Learning

Results indicated a significant main effect for agent, $F(1, 85) = 13.33$, $p<.001$ and for tutorial, $F(1, 85) = 38.34$, $p<.001$. A significant interaction effect between agent and tutorial type was also present: $F(1, 85) = 5.70$, $p = .019$.

Participants recalled significantly more information when interacting with the artist agent, M=7.07 (SD=5.21), than with the scientist agent, M=4.27 (SD=4.03). Additionally, learners recalled more information when participating in the punk rock tutorial, M=7.86 (SD=5.25), than in the nanotechnology tutorial, M=3.05 (SD=2.47). For the nanotechnology tutorial, participants assigned to the scientist group and participants assigned to the artist group received mean recall scores of 2.48 (SD=1.81) and 3.59 (SD=2.91) respectively. For the punk rock tutorial, participants assigned to the artist group and participants assigned to the scientist group received mean recall scores of 10.55 (SD=4.67) and 5.67 (SD=4.71) respectively. Figure 3 presents the difference in scores across the four experimental conditions.

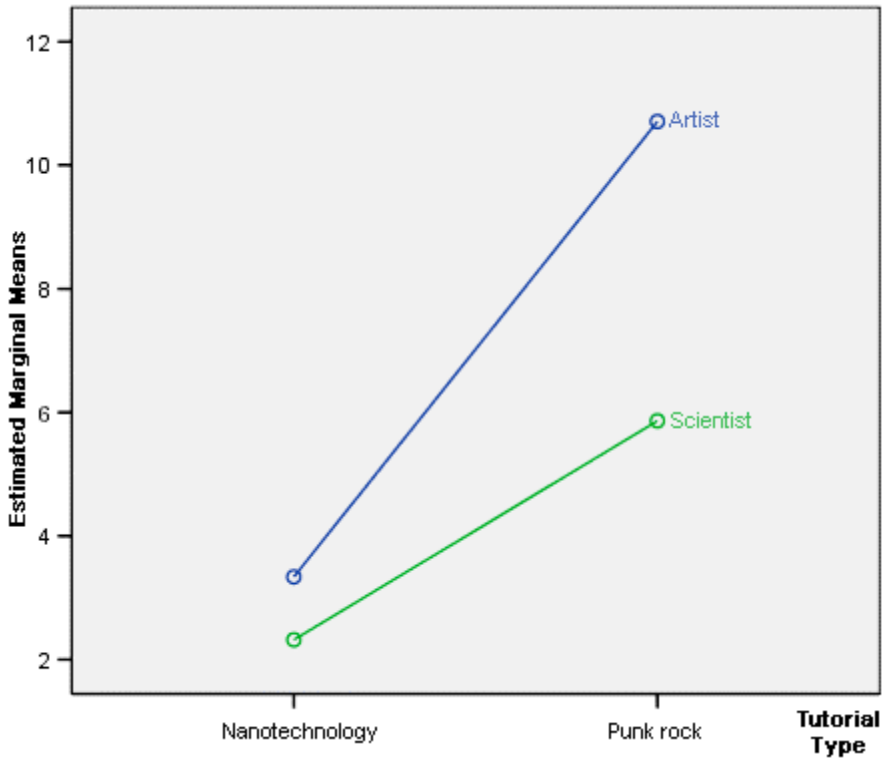

Figure 2. Estimated marginal learning means per experimental condition

4.3 First impressions and stereotypes

Follow-up tests indicated a significant main effect for agent, $F(1, 85) = 9.88$, $p=.002$ and a significant interaction effect between agent and tutorial type, $F(1, 85) = 12.19$, $p = .001$. There was no main effect for tutorial alone [$F(1, 85) =.75$, $p = .39$].

Independent of tutorial, the artist agent was rated as being more knowledgeable, M=3.64 (SD=.65), than the scientist agent, M=3.15 (SD=.77). For the nanotechnology tutorial, participants assigned to the scientist group reported mean perceived agent knowledge of M=3.38 (SD=.74), and participants assigned to the artist group reported mean perceived agent knowledge of M=3.36 (SD=.58). For the punk rock tutorial, participants assigned to the artist group rated the artist agent significantly higher, M=3.91 (SD=.61), than participants assigned to the scientist

group, M=2.96 (SD=.76). The last two results extend Epleya's and Krugerb's (2005) findings that individuals form expectations and stereotypes based on non-verbal cues to the pedagogical agent field. Figure 3 presents a visual depiction of participants' stereotypic expectations regarding agents' perceived knowledge, highlighting the notion that agent appearance matters (Branham, 2001) in relation to learner perceptions.

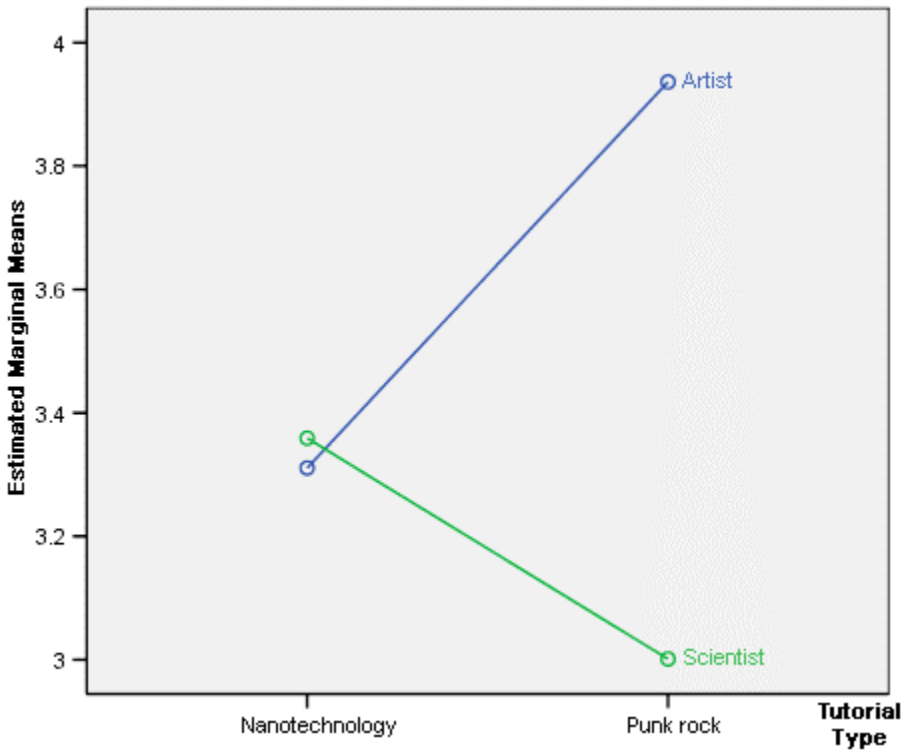

Figure 3. Estimated marginal knowledge means per experimental condition

Responses to the researcher's request to rationalize the rating given to each agent with regard to each tutorial were divided into two camps: participants *either* gave neutral ratings because of their stated unwillingness to draw conclusions on an agent based on his/her visual appearance, *or* gave high/low ratings because of their stereotypical expectations. Even though

participants' responses seem to partially support the quantitative data presented above, they provide a rich description of the complex nature of stereotyping.

The majority of participants' responses were concerned with how context and image influenced student perceptions. Regarding the nanotechnology-scientist agent, one participant commented,

> Appearance can tell you a lot about a person. He looks clean shaven, well kept and put together, and he is wearing a lab coat. Yes, looks can be deceiving but I think he looks like he is rather knowledgeable.

Participants' comments regarding the nanotechnology-artist agent indicated a negative stereotype, "Having a mohawk and blue hair makes him look like he wouldn't know anything about it. I wouldn't walk up to a person looking like that to ask for science help." Nevertheless, it is worth noting that some participants also considered non-stereotypical looks as portraying a sense of intellect, "I have found that some of the smartest people I know fall into a very non-conventional sort of look. From tattoos to long blonde hair, people are always surprising you out of your stereotypical norms." Regarding the punk rock tutorial, participants were quick to identify that the scientist agent did not fit their stereotypical expectations: "This guy is not part of the punk rock culture. I determined this from his clothes and 'clean cut' look." More specifically, one participant noted that "punk rockers, and those associated with punk rock, typically have spiked hair, colored hair, and wear black. The white 'doctor's coat' makes me think he is more of a conformist than a nonconformist." On the other hand, one student placed emphasis on the scientist agent's clothing to explain a high punk rock knowledge rating: "The way the man is dressed and groomed can be considered trendy. He seems like a man who would be updated on a lot of different music types." The explanations given for the artist agent's ratings were generally

more stereotypical. One student noted that “the agent's appearance contains many of the stereotypic 'punker' aspects” while another further explained, “He looks like a person who is knowledgeable in punk rock. His facial features make him look confident and his look (hair) makes him look like he has a background in punk rock.” Nevertheless, qualitative data also revealed two instances where participants appeared to question the artist agent’s visual characteristics in relation to the subject matter under investigation. One of those two respondents noted,

> Just because the agent has blue hair and a mohawk it does not mean he is knowledgeable about punk rock music. The clothes, a dress shirt and coat, he is wearing tell me that he is a poser and probably does not know very much.

Fifteen percent of participants gave neutral knowledge ratings to agents because they felt as though they could not draw conclusions based on visual appearance. One participant assigned to the nanotechnology-scientist group stated, “I do not base a judgment on a person just by looking at him/her. I would rather talk with the person about his/her experiences about the information,” while another noted that “there is no way of knowing his intelligence just by looking at him.” Similarly, participants in the nanotechnology-artist condition remarked that “just because he is wearing a white coat does not necessarily mean that he is knowledgeable about the subject,” while commenting that “knowing nothing about this character, I cannot make judgments simply based upon his appearance.” Another participant summarized, “It is impossible to gauge someone's knowledge about anything based on their appearance. Not only is it impossible, it is dangerous.” Participants assigned to the punk rock - scientist condition made similar comments,

> I'm undecided about whether or not this character is knowledgeable about punk rock. He does not have the stereotypical looks of someone who knows a lot about punk rock, but he could still know a lot about it. You can't judge someone's knowledge of something simply by how they look,

and, “I have no idea about this person...he could be mentally disabled or be a genius. I cannot tell from this picture.” The same pattern was visible in the punk rock-artist condition with one participant providing a similar example: “You can’t judge a book by its cover. Just because I stand in a garage does that make me a car? He may look like a punk rock person but his credibility is not known.”

5. Implications

5.1 Visual appearance and contextually relevant agent representations

The evidence presented in this paper indicates that researchers and practitioners need to pay attention to pedagogical agents’ visual appearance. The visible characteristics of an agent, in relation to the content area under consideration, appear to influence learner perceptions and learning. Hence, it is not enough to merely attach an anthropomorphic image to a tutorial or an intelligent tutoring system. Agent designers need to examine the assortment of non-verbal messages relayed by an agent’s appearance and question those messages with respect to relevance, stereotypes, and equity (Gulz & Haake, 2009; Veletsianos 2007). For instance, in relation to agent gender and ethnicity, Moreno and Flowerday (2006) recommend that “multimedia programs should carefully limit the amount of social cues presented in software agents rather than add them for reasons of appeal or entertainment.” This study supports and extends Moreno and Flowerday’s recommendation to pedagogical agent interfaces that are in

accordance with the domain under investigation. The evidence presented here suggests that a contextual agent representation influences student expectations, impressions, and learning.

5.2. Agents in future research

The results of this investigation provide evidence that pedagogical agent representations need to be examined more meticulously. Researchers often make comparisons between agent representations that are visually different, without examining the impact those representations have had on participant perceptions and behavior. Since this research found that there are differential effects even when two agents derived from the same image are used, results may be confounded when more noticeable differences exist between agent images. For example, researchers should be wary about comparing outcomes across agent genders and anthropomorphic representations (e.g., human vs. inanimate object). This research indicates that even in the cases where similar agents are used, clothing and agent representation may influence learners' attention, allowing for differential learning effects.

6. Limitations

This research study is not without limitations. Researchers and practitioners are encouraged to take into account the following caveats when considering this work.

6.1. Consistently higher artist ratings

The consistency of the artist agent being rated higher than the scientist agent and allowing participants to earn higher scores in the recall task may indicate that the content area under consideration plays a less important role than hypothesized. One could argue that the artist agent was visually more interesting than the scientist agent, directing attention to the task. On the other

hand, these results could be viewed with a Similarity Attraction Hypothesis lens (Moreno & Flowerday, 2006): It is possible that participants identified themselves better with (a) the artist agent rather than with the scientist agent (e.g., by associating with characteristics that are aligned with the agent's image, such as the agent being rebellious and free-spirited), or (b) with the music content than with the science content (e.g., by being more interested on the topic presented).

6.2 Subcategories of stereotypes

Stereotypes within a content area were considered to be uniform, but it is likely that varying stereotypes exist within a specific area. For example, within the punk rock domain, individuals may have access to stereotypes associated with emo rock, pop culture rock, and indie punk rock. These subcategories may include different positive and negative stereotypes and as such may have enabled participants to access different schemata. For example, previous research has reported on evidence regarding subcategories of ethnicity stereotyping (Devine and Baker, 1991). In the light of such an indication, a more fine-grained approach on stereotypes may be more fruitful in assisting researchers to determine further differences between contextual and non-contextual pedagogical agents.

6.3. Agent Depiction

While agent clothing was kept the same across agents so as to avoid confounding the results, it is important to note that it may have introduced conflicting visual information in the context of the agent purported to be an expert in the field of punk rock. In other words, agent clothing and not just facial appearance may have influenced the way learners viewed the scientist agent and

therefore impacted the results. While this possibility is a limitation of the present study, it further highlights the importance of visual appearance and representation on learning outcomes and experiences, and draws attention to the need for research on the area.

7. Conclusion

This study examined the extent to which contextual and non-contextual pedagogical agents influence student learning and impressions. Theoretical underpinnings and evidence from social psychology and human-computer interaction indicated that learners would categorize and stereotype pedagogical agents based on a set of non-verbal cues. It was hypothesized that pedagogical agents that are aligned with the content area under investigation (contextually relevant agents) would enable participants to learn more than agents that are contextually irrelevant. The results of this research indicate that participants categorized the artist agent as being more knowledgeable than the scientist agent under the punk rock condition. On the other hand, this result was scarcely evident in the nanotechnology condition as the two agents were rated as being virtually equally knowledgeable. Finally, participants in the artist agent groups learned significantly more than participants in the scientist groups. Notably, this difference in scores was accentuated between the nanotechnology tutorial and the punk rock tutorial.

While this investigation presented evidence that learners apply stereotypes to pedagogical agents, especially when agents function within a well-defined and articulated academic domain, this evidence should be taken with caution. Before drawing any conclusive remarks regarding the application and impact of contextual anthropomorphic interfaces in educational settings, this line of research needs to be extended. Would first impressions and stereotypes work differently in different domains? Would learners apply stereotypes to non-human agents? Would pedagogical

agent stereotyping persist over time? Finally, numerous other pedagogical agent features may activate stereotypes. For example, would the presence of eyeglasses on pedagogical agents relay the perception of intelligence, and would this perception influence learning and perceptions of pedagogical agent efficacy? Ultimately, the increasing use of virtual characters in electronic learning environments, video games, and virtual worlds renders virtual characters' external representations too significant to ignore.

References

Alvarez-Torres, M., Mishra, P., & Zhao, Y. (2001). Judging a book by its cover: Cultural Stereotyping of interactive media and its effect on the recall of text information. *Journal of Educational Multimedia and Hypermedia, 10*(2), 161-183.

Bandura, A. (1977). *Social Learning Theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bonito, J. A., Burgoon, J. K., & Bengtsson, B. (1999). *The role of expectations in human-computer interaction*. Paper presented at GROUP '99: International Conference on Supporting Group Work, Phoenix, AZ.

Branham, S. (2001). Creating physical personalities for agents with faces: modeling trait impressions of the face. In *Proceedings of the UM 2001 Workshop on Attitudes, Personality and Emotions in User-Adapted Interactions*. Sonthofen, Germany. Retrieved on December 10, 2008 from http://www.di.uniba.it/intint/sonthofen/brahnam-f.pdf

Craig, S. D., Cholson, B., & Driscoll, D. M. (2002). Animated Pedagogical Agents in multimedia educational environments: Effects of agent properties, picture features and redundancy. *Journal of Educational Psychology, 94*(2), 428-434.

Dehn, D., & van Mulken, S. (2000). The impact of animated interface agents: a review of empirical research. International *Journal of Human-Computer Studies*, 52, 1-22.

Devine, P. G. (1989). Stereotypes and Prejudice: Their automatic and controlled components. *Journal of Personality and Social Psychology*, 56, 5-18.

Devine, P.G., & Baker, S. M. (1991). Measurement of racial stereotype subtyping. *Personality and Social Psychology Bulletin, 17*(1), 44-50.

Epleya N., & Krugerb, J. (2005). When what you type isn't what they read: The perseverance of stereotypes and expectancies over e-mail. *Journal of Experimental Social Psychology*, *41*, 414-422.

Gladwell, M. (2005). *Blink: the power of thinking without thinking*. New York, NY: Little, Brown, and Company.

Gulz, A. (2004). Benefits of virtual characters in computer based learning environments: Claims and evidence. *International Journal of Artificial Intelligence in Education, 14*, 313-334.

Gulz, A., & Haake, M. (2006). Design of animated pedagogical agents - A look at their look. *International Journal of Human-Computer Studies*, *64*(4), 322-339.

Haake, M., & Gulz, A. (2008). Visual stereotypes and virtual pedagogical agents. *Educational Technology & Society*, *11*(4), 1-15.

Hamilton, D.L., & Sherman, S.J. (1996). Perceiving persons and groups. *Psychological Review*, *103*, 336-355.

Jennings, N., and Collins, C. (2008). Virtual or Virtually U: Educational Institutions in Second Life. *International Journal of Social Sciences, 2*(3), 180-186.

Lavie, T., & Tractinsky, N. (2004). Assessing dimensions of perceived visual aesthetics of web sites. *International Journal of Human-Computer Studies, 60(3),* 269-298.

Lester, J., Converse, S., Kahler, S., Barlow, T., Stone, B., & Bhogal, R. (1997). The persona effect: Affective impact of animated pedagogical agents. *Proceedings of Human Computer Interaction, Association for Computing Machinery, 1997,* 359-366.

Louwerse, M.M., Graesser, A.C., Lu, S., & Mitchell, H.H. (2005). Social Cues in Animated Conversational Agents. *Applied Cognitive Psychology, 19,* 1-12.

Macrae, C.N., Milne, A.B., & Bodenhausen, G.V. (1994). Stereotypes as energy-saving devices: A peek inside the cognitive toolbox. *Journal of personality and Social Psychology*, 66, 37-47.

Mayer, R. E., Dow, G. T., & Mayer, S. (2003). Multimedia Learning in an Interactive Self-Explaining Environment: What Works in the Design of Agent-Based Microworlds? *Journal of Educational Psychology, 95*(4), 806-813.

Moreno, K. N., Person, N. K., Adcock, A. B., Eck, R. N. V., Jackson, G. T., & Marineau, J. C. (2002). *Etiquette and Efficacy in Animated pedagogical agents: the role of stereotypes.* Paper presented at the AAAI Symposium on Personalized Agents, Cape Cod, MA.

Moreno, R., Mayer, R. E., Spires, H., & Lester, J. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction, 19,* 177-213.

Moreno, R., & Flowerday, T. (2006). Students' choice of animated pedagogical agents in science learning: A test of the similarity-attraction hypothesis on gender and ethnicity. *Contemporary Educational Psychology, 31*(2), 186-207.

Nass, C., Moon, Y., & Carney, P. (1999). Are respondents polite to computers? Social desirability and direct responses to computers. *Journal of Applied Social Psychology, 29*(5), 1093-1110.

Nass, C., Moon, Y., & Green, N. (1997). Are computers gender-neutral? Gender stereotypic responses to computers. *Journal of Applied Social Psychology, 27*(10), 864-876.

Norman, D. A. (1997). How might people interact with agents. In J. M. Bradshaw (Ed.), *Software agents* (pp. 49-56). Menlo Park, CA: MIT Press.

Parrish, P. (2008). Aesthetic principles for instructional design. *Educational Technology Research and Development.*

Plant E., Baylor A.L., Doerr C.E., & Rosenberg-Kima R.B. (2009). Changing middle-school students' attitudes and performance regarding engineering with computer-based social models. *Computers and Education, 53* (2), pp. 209-215.

Reeves, B., & Nass, C. I. (1996). *The media equation: How people treat computers, television, and new media as real people and places*. Cambridge: Cambridge University Press/CSLI.

Rickel, J., & Johnson, L. (2000). Task-oriented Collaboration with Embodied Agents in Virtual Worlds. In Cassell, J., Sullivan, J., Prevost, S. and, Churchill, E. (Eds), *Embodied Conversational Agents* (pp. 95-122). Cambridge MA: MIT Press.

Ritts, V., Patterson, M., & Tubbs, M. (1992). Expectations, impressions, and judgments of physically attractive students: A review. *Review of Educational Research, 62*(4), 413-426.

Rosenberg-Kima, R., Baylor, A., Plant, A., & Doerr, C. (2008). Interface agents as social models for female students: The effects of agent visual presence and appearance on female students' attitudes and beliefs. *Computers in Human Behavior, 24*(6), 2741–2756.

Sweller, J. (1994). Cognitive load theory, learning difficulty and instructional design. *Learning and Instruction, 4*, 295-312.

Veletsianos, G., & Miller, C. (2008). Conversing with Pedagogical Agents: A Phenomenological Exploration of Interacting with Digital Entities. *British Journal of Educational Technology, 39*(6), 969-986.

Veletsianos, G. (2007). Cognitive and Affective Benefits of an Animated Pedagogical Agent: Considering Contextual Relevance and Aesthetics. *Journal of Educational Computing Research, 36*(4), 373-377.

Willis, J., and Todorov, A. (2006). First impressions: Making up your mind after 100 ms exposure to a face. *Psychological Science, 17* (7), 592-598.