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The Impact of Pedagogical Agent Image on Affective Outcomes

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ABSTRACT
In this paper, we summarize and interpret results from six experimental studies that investigate the impact of pedagogical agent image on affective and motivational outcomes. The evidence to date suggests that the image of an interface agent should be carefully designed while considering student characteristics for optimal affective interactions. Preliminary design guidelines with respect to agent gender, ethnicity and realism are provided, based on the most salient results.

Keywords
Agent, pedagogical agent, social interface, image, human-computer interaction, motivation, evaluation, user studies

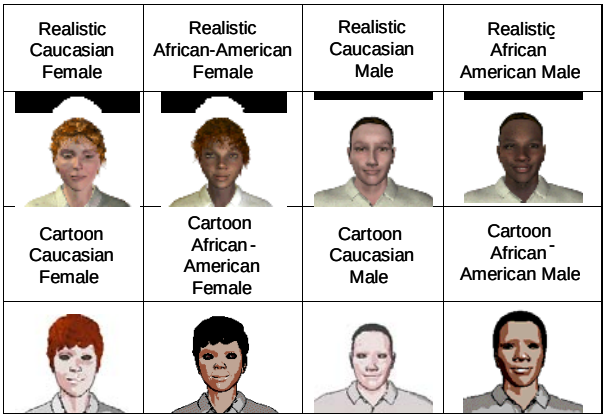
INTRODUCTION
Pedagogical agents are animated life-like characters designed to facilitate learning in computer-mediated learning environments [1]. Recent work has systematically examined the effects of agent interface features, including role/functionality [2], affective support [3], voice [4, 5], and animation [4, 6]. The focus in this paper is on the impact of pedagogical agent image on learner motivation/attitude, and perceptions.

The purpose of this paper is to interpret the impact (both statistically and practically) of image-related findings from six experimental studies conducted by the PALS (Pedagogical Agent Learning Systems) Research Group, which is part of the Center for Research of Innovative Technologies for Learning (RITL) -see http://ritl.fsu.edu/about_pals.html. These studies have focused on the impact of agent *image* from several perspectives, including: 1) the gender, ethnicity, and realism of the agent (Studies I-III); 2) user expectations and stereotypes of the agent based on its image (IV); and, 3) learner perceptions when the image is a non-human figure (e.g., object or animal) (V & VI).

THE EFFECTS OF REALISM, GENDER, AND ETHNICITY
Agent realism, gender and ethnicity were systematically examined in three research studies. In the first two studies, contrasting research approaches [7, 8] were employed to assess the role of agent realism, gender, and ethnicity: 1) a choice study, where users could choose the agent that they desired to learn from, and 2) an experimental study, where users were randomly assigned an agent that varied on the three dimensions. In the third study, the agent's message was also manipulated, to assess how its functionality interacts with agent gender, realism, and ethnicity.

For Study 1 & 2, eight three-dimensional pedagogical agents were developed in Poser to represent the three agent characteristics: ethnicity (African-American and Caucasian), gender (female and male), and realism (realistic and cartoon). The agents (see Figure 1) were created by a graphic artist from the same facial image, differing only in skin color, hair color, and details of the face structure in order to represent ethnicity, gender and realism. Each agent had an identical message, identical lip-syncing, and identical animations. Each female agent had identical computer-generated voice, as did each male agent.

Figure 1. Agents Differing by Realism, Gender, Ethnicity



Study 1: Giving Students a Choice of Agents
In the first study, 183 undergraduates (54% Caucasian, 37% African American, and 9% other) were asked to "pick the instructor you would like to learn from" with all eight agents on-screen. After the learners chose the agent instructor, they were prompted "why did you choose this instructor?" After answering the question, the chosen agent

instructor gave a presentation on coping with college life. After the presentation, the learners assessed the agent's persona according to the four psychometrically-validated factors of human-like, credibility, engaging, and facilitating learning (see [11]).

Regression results revealed that students tended to choose an agent of the same ethnicity as themselves. However, after learning from the chosen agent, African-American students were significantly more likely to rate their chosen agent as more facilitating of learning, more credible, more human like, and more engaging, than Caucasian students. The effect size for each was large (d>.8), according to Cohen's standards [12].

With respect to why students chose the agent, perceived agent demeanor (e.g., "she looked caring") was the most cited reason overall, followed by agent gender, instructor-related characteristics, and agent ethnicity. However, when analyzed by student ethnicity, it was found that African American students were significantly more likely than Caucasian students to cite both gender and/or ethnicity as the reason for their choice of agent. Representative quotes from these students follow: "I chose this agent because I like to learn from someone that looks like me (in terms of) race and gender," "African American women can relate to me better," and, "African American male teachers can relate better to young African American learners."

By gender, females were more significantly more likely than males to choose a cartoon-like agent (as opposed to realistic agent) than males. In addition, females were significantly more likely than males to mention their personal experience as a reason for their choice of agent than males, and males were more likely to mention instructor-related characteristics. There were no differences, however, in terms of students selecting agents of the same or different gender than themselves.

Study 2: Randomly Assigning an Agent to Students

In the second study, 312 pre-service teachers (53% Caucasian; 33% African-American, 14% other) were randomly assigned to work with one of the 8 agents in a between-subjects design. Students worked with the agent to learn basic instructional planning skills within the MIMIC (Multiple Intelligent Mentors Instructing Collaboratively) environment [13].

For motivational-related outcomes, there was an overall positive effect for the male agents (in contrast to the female agents): students working with male agents had higher reported self-regulation (e.g., evaluation, monitoring, reflection), greater self-efficacy (i.e., confidence toward instructional planning in the future), and rated them as significantly more useful, interesting and leading to more satisfaction. However, all of these effects were small (d<.5) in terms of magnitude. Even so, the overall positive bias toward the male agents is interesting, as it was not found in the prior study where students were given a choice of agent. In other words, in Study 1, students were not more likely overall to *choose* the male agents, yet they rated the male agents higher than the female agents when they were randomly assigned to them.

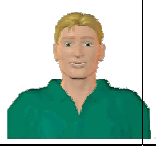
Study 3: Interaction of Agent Role/Functionality with Gender and Ethnicity

In the third study, the factor of agent instructional role/functionality was considered. Here, the message of the agent was manipulated to represent one of 2 instructional roles: Expert or Motivator. Given that people tend to apply the same social rules and expectations from human-human interaction to computer-human interaction [14], we referred to research on human instructors for implications for the agent instructional role design, described in detail in [2, 15].

In brief, the Expert role was operationalized through the image of a professor in forties. His animation was limited to deictic gestures, and he spoke in a formal and professional manner, with authoritative speech. Being emotionally detached from the learners, his function was to provide accurate information in a succinct way. The Motivator role was with a peer-like image of a casually-dressed student in his twenties, considering that our target population was college students with expressive gestures, and enthusiastic/energetic voice. The Motivator was not presented as particularly knowledgeable but as an eager participant who suggested his own ideas and verbally encouraged the learner to sustain at the tasks (e.g. [16])while expressing emotion that commonly occurs in learning, such as frustration, confusion, enjoyment [17].

A set of eight agents that differed by gender, ethnicity, and role, were designed, as shown in Figure 2. Each agent was validated as effectively representing the intended gender, ethnicity, and instructional roles with 174 undergraduates.

Figure 2. Expert and Motivator Agents, Differing by Gender and Ethnicity

Experts		Motivators	
Caucasian Female (ExCF)	African-American Female (ExAF)	Caucasian Female (ExCF)	African-American Female (ExAF)
			
Caucasian Male (ExCM)	African-American Male (ExAM)	Caucasian Male (MoCM)	African-American Male (MoAM)
			

In Study 3, 154 students were randomly assigned to one of the 8 conditions. Students worked with the agent to learn

how to plan instruction for e-Learning. To eliminate confounding effects of different delivery (voice and animation) across the instructional roles, the Motivator and Expert roles were analyzed separately in order to focus on the impact of the image, by agent gender and ethnicity.

For the Motivator agents, results revealed a main effect for agent gender, indicating that the male Motivator agents were perceived as significantly more intelligent, knowledgeable, and expert-like than the female Motivator agents (d=.55). There was also a main effect for agent ethnicity where the African-American Motivator agents were rated as significantly more enjoyable, enthusiastic, motivational than the Caucasian Motivator agents (d=.40).

For the Expert agents, there was a main effect for agent gender indicating that those working with the female Expert agents reported greater self-efficacy (confidence) than those working with the male Expert agents (d=.57). Students also rated the female agents as significantly less competent than the male agents. Results also indicated a main effect for agent ethnicity in several areas. Students reported significantly more facilitation of learning (e.g., focus on relevant information, help in concentration) from the African-American Expert agents than from the Caucasian Expert agents (d=.55). Also, students reported more enjoyment in the process (d=.3). Of interest is that students actually learned significantly more with African-American Expert agents than with the Caucasian Expert agents (d=.60).

This study highlights the role of student/user *expectations*, particularly when the agent is represented non-traditionally (e.g., African-American Expert). The role of expectation as it relates to stereotypes is investigated in-depth in the next study.

STUDY 4: STEREOTYPICAL IMAGE AND ATTITUDE CHANGE

In Study 4 [18], 124 female pre-service teachers (average age of 19 years) worked with one of two 3D animated agents that modeled positive beliefs about engineering in a between-subjects design: 1) non-stereotypical female engineer agent, referred to as "Nina," and operationalized as attractive and outgoing; or, 2) stereotypical "geeky" female engineer agent, referred to here as "Geek," and operationalized as homely and introverted. See Figure 3 for pictures of the agents. The purpose of this study was to determine the impact of stereotypical vs. non-stereotypical images on students' attitudes toward engineering.

Figure 3. Agent engineers: 1) Non-stereotypical female and 2) Stereotypical female

In this study, the agent conditions differed by image, but were identical in terms of message, which stressed the relational aspects of engineering and that it contributes to the social good, both of which are appealing to females (e.g., [19]).

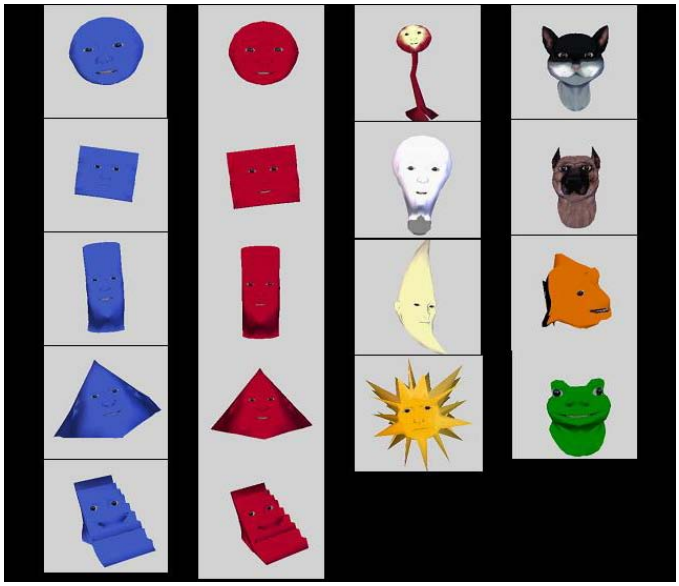
In comparing Nina with the Geek, there were several areas of significant difference. The students who worked with Nina were more likely to believe: that they could be successful as an engineer (d=.69), that they had the intelligence to be an engineer (d=.96); that the program positively influenced their stereotype about engineering (d=1.01), and that they were interested in learning more (d=.66). Interestingly, students interacting with the Geek were more likely to influence their future students (but not themselves) to pursue engineering as a possible career (d=.74). Nina was also perceived as significantly less competent than the Geek.

This result is in line with other results that indicate that students have significant improvement in self-efficacy after working with pedagogical agents who they perceive as less competent than themselves [20, 21]. In addition, given the higher status typically attributed to attractive women compared to unattractive women in our society, these findings are consistent with the finding that people are more likely to model high status others [22].

NON-HUMAN AGENTS

Two separate studies were conducted to assess how non-human agents are interpreted as an interface. For both studies, eighteen different agents (see Figure 4) were developed with PeoplePutty to reflect different color schemes (e.g., red, blue, yellow, green, orange, brown, white and black) and shapes. Thirteen different shaped agents were developed to reflect the degree of complexity of the images. Three of them, (box, can and ball), were simple geometric shapes that reflect low complexity of form; two of them, cat and dog, were realistic shapes that reflect high complexity. All agents were 3D animated images with a human-like face and a computer-generated voice.

Figure 4. Non-human-like Agents, by Color, Shape, Aliveness, and Complexity



Study 5: Semiotic Analysis of the Meaning of Agent Images

The first exploratory study (Study 5) focused on the effect of these non-human agent images on learners' meaning construction, following a semiotic approach. Semiotics is a field to examine how we construct meanings and communicate with signs, and provides the analyst with a conceptual toolkit for systematically approaching sign systems (in this case, the agents) to discover how they produce meaning [23].

In a repeated-measures design, 136 college students were presented with nine agents, one at a time (from the total set of 18 agents). Each set of agents was counterbalanced for shape and color. For each agent, participants responded to the query, "what do you think this figure is" and then were asked to list all words that figuratively "came to mind" regarding the agent image.

Learners' responses were analyzed according to semiotic analysis, categorization, and a semantic differential technique. Results indicated that learners were more likely to match the intended meaning of the image when it was complex in nature. Learners' responses as to the meaning of the images tended to fall in one of two categories: emotion-related (e.g., fun, happy, sad, excited, cute, pleasant) or word associations (e.g., spoon, star, dinosaur, ocean, beach, cherry). The result of the semantic differential method indicated that, in general, learners had a positive attitude toward the impersonal agents. They felt that the agents had relatively "bright" and "calm" images, rather than "dark" and "anxious" images; also, they thought agents were "cute" and "smart", rather than "ugly" and "dumb."

Of interest is that even though these images were non-human, the learners still used linguistic terms that were directly related to human emotion. This implies that learners were stimulated affectively by the seemingly impersonal images. In contrast, the *lack* of cognitive words used by learners implies that they were not particularly engaged cognitively. Learners described simple shapes using the terms which were directly related to human characteristics such as nice, calm, happy, etc. However, when they described the two animals, dog and cat, they used the words indicating the relationship with human such as "pet" and "loyal". Learners connected them with learners' personal life using the words "my doggy" and "my favorite pet".

Regarding the complexity of images, simple 3D images tended to be recognized as 2D images. For example, in the case of ball, learners described it as circle, and in the case of box, they tended to describe it as rectangular. Shapes would provide the first impression of the agent images, when the images were simple. When learners named the agent of geometric images, they focus on shapes rather than the associated meaning. However, when they were asked to describe the agent rather than just name it, they thought of colors first and then associated meanings.

Study 6: The Role of Color and Shape

In the second non-human image study, the thirteen different shaped agents were classified into three categories according to the results of previous study: realism: geometric or realistic; color: red or blue; and, complexity: high or low complexity. 191 undergraduate students were randomly assigned to work with one of the eighteen agents, all of which delivered identical content with identical animations and computer-generated voices

Results indicated that participants perceived the more realistic agents (e.g., dog, fish, frog) as more instructor-like. Even though the agent delivered the same instructional messages, a relatively lower number of learners recognized geometric images as instructor-like. Realistic images were more appealing to learners. The shape as well as the texture is a relatively important element of image in making it attractive to learners. Moreover, realistic images tended to engage learners more in the learning activity. In particular, when learners had realistic images, they thought the agents were more interactive and animated. In the aspect of motivation, learners were more satisfied in their learning activities when they learned from the realistic agents (d=.45).

Gender also influenced learners' perception of agent appearance. Female learners tended to be more aware of the outer appearance of the images and tended to be more attracted by the agent appearances. Shapes influenced learners' engagement in the learning activity. High complexity images seemed to provide learners with a more favorable learning environment. In this study, color did not impact the learners' emotion or the agents' emotion as perceived by the learners.

DISCUSSION

These studies did not employ intelligent interfaces intentionally in order to produce more generalizable results across a variety of adaptive interfaces. Overall, results suggest a need to consider individual differences in learning with social interfaces. Student gender and ethnicity play a role in how students (and other users) may respond system interfaces.

From a design perspective, it is critical to first consider the desired outcome for the interface. Allowing students/users to make the choice of what they perceive as "best" is risky (e.g., students may tend to choose agents of the same ethnicity, yet may learn more from agents of different ethnicity).

Design recommendations from these results are based on whether the intended outcome is motivational (or affect-related), or perceptual. Of all the statistically significant findings, only those with effect sizes of medium or large (based on Cohen's d-value) are listed here as tentative design recommendations.

For *motivational* outcomes (e.g., attitude, satisfaction, confidence, and interest), findings from these studies suggest:

1. Providing a choice of agents may be particularly beneficial for African-American students, who tend to affiliate strongly with the agent that they choose; Caucasian students, in contrast, may choose agents (e.g., those of similar ethnicity) that are not in their best interest.
2. Providing a non-stereotypical agent can surprise students with respect to their expectations, leading them to have increased self-efficacy (confidence) and interest toward the topic. In general, results show that female agents are perceived as less competent, and thus more likely to positively influence learner self-efficacy (e.g., female Expert agents vs. male Expert agents).
3. For non-human images, realistic (i.e., rich, "alive" images such as animals) lead to greater satisfaction than geometric (e.g., ball, cube, cylinder) images.

From a perceptual standpoint, the non-human agent studies illustrated that students tend to identify with the non-human agents emotionally, even when they are not particularly anthropomorphic, as supported by [14]. African-American students appear to have a particularly strong affinity towards agents of the same ethnicity, and rate them as more credible and human-like. Caucasian students also prefer agents of the same ethnicity, yet this is not necessarily to their benefit, as it is for African-American students to work with similar agents. For non-human images, the realistic images (i.e., rich, "alive" images such as animals) were perceived as more instructor-like than the geometric images. This is similarly supported in [6] where the presence of agent animation (thus, making the agent more realistic) leads to user perceptions that the agent is more instructor-like.

A key ethical issue is how to reconcile user/student expectations. Existing societal stereotypes suggest that females (and, subsequently, female agents) are assessed as less competent than male agents. As a result, the presence of female agent interfaces may lead to increased user/learner self-efficacy (confidence) in the content area [2, 21, 24]: i.e., "if she can do it, I can do it!" However, this does not seem to be a stereotype that is beneficial to disseminate.

Similarly, designing interface agents in non-stereotypical roles (e.g., the "sexy" engineer agent, Nina) may lead to desired attitudinal, but could have more detrimental effects in the long-term for females' beliefs toward women in demanding careers. In contrast, having Experts be represented by African-Americans (or another minority) could lead to increased learning for student *and* positively affect beliefs toward accepting diversity in these roles.

For all of these studies, it is important to realize there are several important limitations. These studies implement a particular instantiation of agent images, from a potential unlimited set of images. Thus, these studies need to be replicated with different agent instantiations and different learner/user populations.

Overall, more research is needed that considers bother learner/user factors (e.g., gender, ethnicity) *together with* interface features. Studies such as these require very large sample sizes, but have the potential to illuminate generalizable design principles.

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