The Influence of Computer-based Model's Race and Gender on Female Students' Attitudes and Beliefs Towards Engineering

RINAT B. ROSENBERG-KIMA, E. ASHBY PLANT, CELESTE E. DOERR, AND AMY L. BAYLOR
Florida State University

BACKGROUND
This study explored the use of interface agents, anthropomorphic, 3D-animated computer characters that provide teaching or mentoring within a computer-based learning environment, to encourage young Black and White women to pursue careers in engineering.

PURPOSE (HYPOTHESIS)
We hypothesized that computer-based models that matched young women in terms of their race and gender would be the most effective in positively influencing their interest, self-efficacy, and stereotypes about engineering.

DESIGN/METHOD
Eighty African American undergraduate female students in Experiment 1, and 39 White undergraduate female students in Experiment 2 interacted with a computer-based agent that provided a narrative designed to encourage them to pursue engineering careers. The study employed a 2×2 between subjects factorial design (agent gender: male vs. female and agent race: Black vs. White).

RESULTS
Across both studies we found that race and gender influenced the effectiveness of the agent for several key outcome measures. Computer-based agents who matched the participants with respect to race and gender tended to be the most effective in improving the women's responses to engineering-related fields. Nevertheless, the White male agent was actually significantly more influential than the White female agent for female Black participants.

CONCLUSIONS
Personalizing interface agent characteristics to match the target population can increase the effectiveness of a persuasive message to encourage young women to pursue engineering. Such an approach may contribute to the growth and inclusiveness of fields such as engineering.

KEYWORDS
animated pedagogical agents, interface agents, persuasion

I. INTRODUCTION

Women and minorities remain under-represented in the field of engineering. Only 8.5 percent of all professional engineers are women, although women constitute 56.8 percent of the total workforce (Goodman et al., 2002). In 2006, only 7 percent of engineering managers were women (Elaine and Philip, 2007). This absence of women in engineering is also evident in educational settings. Even though women are more likely than men to attend college, men earned the majority of bachelor's degrees awarded in engineering (80 percent) (NSF, 2008). Similarly, for minority representation, according to the National Science Foundation (NSF) Indicators report (NSF, 2000; 2003; 2008), African Americans, Hispanics, and Native Americans constitute 24 percent of the total workforce but just 7 percent of the science and engineering workforce. In 2001 African Americans earned 8.8 percent of all bachelor's degrees in the United States but only 5.3 percent of engineering degrees (MentorNet, 2004). The representation of female minority group members is lower still. According to NSF reports, African American, Hispanic, and Native American women made up only 2 percent of the science and engineering workforce (NSF, 2000; 2003).

Women's and minority group members' under-representation in engineering may result in part from their negative beliefs regarding the field of engineering and their ability to succeed in this field (Shashaani, 1997). The current work explores an approach to encourage young women to pursue careers in engineering. Generally, this approach targets women's negative beliefs about engineering and their lack of confidence in their own abilities using computer-based anthropomorphic social models. These models are animated computer characters that provide teaching or mentoring within a computer-based learning environment. The goal is to challenge female students' stereotypes about engineering and improve their perceived self-efficacy regarding engineering-related academic subjects. In the current work, we were particularly interested in whether this approach can be tailored to increase its effectiveness for women from racial minority groups, particularly African American women. Specifically, this study explored the impact of the race and gender of the social model on its effectiveness. We predicted that computer-based models that matched young women in terms of their race and gender would be the most effective in positively influencing their interest, self-efficacy, and stereotypes about engineering.

A. Stereotypes and Self-Efficacy

Previous work provides some insights into why women may be less likely than men to pursue engineering. For example, women's under-representation in engineering and related fields may be partially due to the effects of occupational stereotypes and the traditional male domination in the fields. Women tend to sex-type science as a masculine pursuit (e.g., Hughes, 2002) and negate the utility of mathematics (Eccles, 1994). Engineering and scientific fields are generally stereotyped as physically challenging, unfeminine, and aggressive (Adams, 2001). They are perceived as object-oriented rather than people-oriented (Lippa, 1998). Engineering is viewed as a field lacking in social responsibility and contribution to environmental problems (Hersh, 2000). Additionally, the current under-representation of women in engineering may foster the impression that engineering is an unusual career for women (Byrne, 1993). While some of their male contemporaries view female scientists as "honorary men," other see them as "flawed women" (Etzkowitz, Kemelgor, and Uzzi, 2000).

Due in part to their under-representation when pursuing a career in engineering, women face gender-related barriers throughout their development (e.g., lack of role models, social isolation) that may divert them from their path at multiple points along the way (Etzkowitz, Kemelgor, and Uzzi, 2000). Mcllwee and Robinson (1992) further argue that women view a conflict between their gender role and the characteristics perceived as important for success in an engineering career (e.g., assertiveness and a fascination with technology), which tend to be associated with the male gender role. In addition, they argue that because engineering is highly male-dominated, men tend to create a workplace culture that is very male-identified, which puts women at a disadvantage. Thus, for many reasons, the existing under-representation of women in the field may discourage female students from pursuing it.

Female students' levels of self-efficacy regarding math, science, and engineering may also affect their intentions to pursue engineering careers (e.g., Hutchison, Follman, and Sumpter, 2006). Self-efficacy refers to the belief that one is competent to meet situational demands (e.g., Bandura, 1977; Wood and Bandura, 1989). Female engineering students tend to perceive themselves as less competent than their male peers (Goodman et al., 2002). Low self-efficacy in math, science, and engineering begins early for female students. Girls as young as elementary age tend to underestimate their math ability, even though their actual performance may be equivalent to that of same-aged boys (Eccles, 1987; 1994). At the college level, Besterfield-Sacre and colleagues (2001) found that female first year engineering students self-reported lower competency on basic engineering skills and knowledge, problem solving ability, and engineering abilities compared to male first-year students, even though objective assessments of their abilities did not differ from those of the men. Additionally, female students tend to believe that math and engineering aptitudes are fixed abilities, thus attributing failure or success to stable factors (Heyman, Martyna, and Bhatia, 2002). Further compounding these issues, Black women's self-confidence may also be undermined by the perception that White faculty and students regard Black students as having lower ability (Seymour and Hewitt, 1997).

Self-efficacy is also likely to affect educational outcomes for women who do actually choose to become engineering majors. Goodman and colleagues (2002) found that female engineering students who abandoned their major believed their male peers to have more ability and comprehension of concepts than themselves, even though 66 percent of these female students earned an A or B average. Among female students, the most influential factor that determined attrition was not course grades, but level of self-confidence. Seymour and Hewitt (1997) similarly described women's experience of diminished self-esteem, self-confidence, and career ambitions as playing a critical role in their decision to leave the discipline, despite good academic performance. Likewise, Marra et al. (2009) found that female engineering students with low self-efficacy are less likely to report their intention to persist in obtaining their engineering degrees.

B. Computer-Based Models as Persuasive Tools

One possible approach to improving young women's attitudes and self-efficacy towards engineering is to provide them with a social model who is both similar to them and that represents an engineer. People do not only learn through their own experiences but can learn vicariously by observing others perform behaviors and then copying or modeling those behaviors (e.g., Bandura, 1977; 1986). Social modeling of behaviors enables us to learn new behaviors, strengthens or diminishes previously learned behaviors, and reminds us to perform behaviors about which we had forgotten (Bandura, 1997). Mentors in academic and work settings can be important social models and the research on mentoring demonstrates how effective good social models can be in encouraging women and minorities in engineering. Mentors with advanced experience and knowledge who are committed to providing upward support were found to have an important role in enhancing career satisfaction, especially for women engineers (Ingram, Bruning, and Mikawoz, 2009). One of the important roles that mentors play is to enhance an individual's sense of competence, identity, and effectiveness (Kram, 1985).

Trenor and colleagues (2008) found that access to role models is a recurring theme that women and minorities list as influencing their decision to select Engineering as their major (also see Etzkowitz, Kemelgor, and Uzzi, 2000). Observing a social model perform a behavior provides people with information relevant to their likely self-efficacy for similar behaviors (Bandura and Schunk, 1981). Not all potential social models are similarly effective, however. People tend to learn from others who resemble them closely or who match their ideal image (Bandura, 1986; Mussweiler, 2003; Schunk, Hanson, and Cox, 1987; Wood and Bandura, 1989). Thus, the small number of women in engineering classes may create in itself additional difficulties and result in women, especially Black women in engineering, lacking peers, faculty role models, and mentors (Seymour and Hewitt, 1997).

Although it would be ideal to provide young women in fields such as engineering with a human social model and mentor that matches their gender and race, this may be difficult because of the shortage of similar models. In addition, asking young professional women in the fields such as math, the hard sciences, and engineering to act as mentors would be problematic because it would contribute to the already-burdensome workloads faced by women in nontraditional fields (Hersh, 2000). In addition, the increased use of technology in the classroom as well as online learning calls for a solution that may utilize and be easily integrated into these technologically advanced models of learning. Therefore, it would be useful to find alternative mechanisms for providing social models that are both easily accessible for a large population of students and that can be personalized depending on the individual needs of the students.

Interface agents, which are anthropomorphic, 3D-animated computer characters that provide teaching or mentoring within a computer-based learning environment, can potentially serve as simulated social models to impact learning, beliefs, and attitudes. Extensive research has demonstrated that people tend to apply human social rules to computer technologies (e.g., Baylor and Kim, 2009; Nass and Lee, 2001; Nass and Moon, 2000; Nass et al., 1995; Reeves and Nass, 1996). For example, Nass and his colleagues demonstrated that individuals apply gender stereotypes to computers (Nass, Moon, and Green, 1997), ethnically identify with computer agents, and exhibit social behaviors toward computers (Nass and Moon, 2000). In addition, students interacting with animated pedagogical agents exhibit deeper learning and higher motivation (Atkinson, 2002; Baylor, 2002; Baylor and Kim, 2009; Johnson, Rickel, and Lester, 2000; Moreno et al., 2001). Moreno and colleagues (2001) found that interactive pedagogical agents who communicate with students via speech can be used to promote meaningful learning in multimedia lessons. Atkinson (2002) demonstrated how an animated agent programmed to deliver instructions orally can help optimize learning from examples. Baylor and Kim (2005) found that pedagogical agents that are designed as mentors led to overall improved learning and motivation. Particularly relevant to the engineering context, recent empirical evidence also indicates that interface agents can positively influence young women's interest, motivation, and even self-efficacy regarding engineering (Baylor and Plant, 2005; Rosenberg-Kima, Baylor, Plant, and Doerr, 2008).

The current work is guided by the principle that, because people apply human social rules to human-computer interactions, social-learning rules should also apply to people's interactions with computerized interface agents. Given a visibly present agent, research in social psychology suggests that the agent's characteristics would be important in determining how persuasive a social model is for influencing young women's engineering-related beliefs (Bandura, 1997; Chaiken, 1979; McIntyer, Paulson, and Lord, 2003). In general, people are persuaded more by social models that are similar to them or similar to their ideal image (e.g., Bandura, 1986; Mussweiler, 2003; Schunk, 1987; Wood and Bandura, 1989). Others who are perceived as similar also provide information to observers about whether or not tasks are behaviorally appropriate for them (Schunk, 1987).

There is also evidence that interface agents can positively influence college age women's beliefs and attitudes and that women may be more influenced by them than men (Baylor, 2002; 2005). Baylor (2005) found that interface agents were effective in improving young women's attitudes and beliefs about engineering-related fields. Rosenberg-Kima et al. (2008) found that the agent models that were similar to the young women (i.e., female, young, and "cool") tended to be the most effective for influencing the women's attitudes and beliefs about engineering. In particular, the female agents were the most effective for influencing the women's stereotypes about engineering, and the young and "cool" agents were the most effective for influencing their self-efficacy and interest in the field. Therefore, interface agents, as simulated social models who are similar to the young women may be particularly helpful in promoting young women's attitudes and self-efficacy with respect to engineering.

C. Purpose of Study

To date, scant research has examined the role of the agent race in affecting the ability of agents to influence attitudes and beliefs. There is reason to believe that similarity of race may be important for increasing the efficacy of agents. Previous work demonstrates that people are more likely to be affected by others who are perceived as similar when an attitudinal, value-related issue is the object of influence (Goethals and Nelson, 1973). In addition, Marx and Goff (2005) found that when a Black experimenter gave a verbal test to Black participants they performed better than when a White experimenter gave the test. Likewise, Wilder (1990) found that subjects exposed to in-group communicators attributed greater independence to them, made fewer errors in recalling their messages, and clustered recollections of messages by individual speaker. Moreno and Flowerday (2006) found that when given the opportunity to choose the ethnicity of an animated pedagogical agent, students of color chose significantly more same-ethnicity agents than agents of another ethnicity. This was not the case for White students who did not tend to pick White agents significantly more than other agents. These findings suggest that students of color may prefer and respond more positively to agents that match as opposed to those that do not match their race. To our knowledge, however, previous work has not randomly assigned agent race to participants and examined the impact of an interface agent's race on participants' attitudes.

As a first step in addressing these issues, in Experiment 1, we presented female African American undergraduate students with an interface agent who encouraged them to pursue engineering. The agents varied in both their gender and race (Black vs. White). We then assessed participants' stereotypes about engineering as well as their self-efficacy regarding engineering and their interest in pursuing engineering. In addition, we assessed the participants' perceptions of the agents and the message. Of interest was whether the participants were more influenced by agents that matched their race and gender as compared to agents that were different than them. Based on the existing research, we anticipated that the Black, female agent would be the most effective for influencing our Black, female participants regarding engineering. The purpose of Experiment 2 was to examine whether the findings would be replicated when the participants were White female students. In other words, we expected that in this case, the female White agent, which is the most similar to the participants in race and gender, would be the most effective in changing the participants' beliefs about engineering.

Thus, for both the experiments we hypothesized that the most similar agent (Black-female agent in Experiment 1 and White-female agent in Experiment 2) would be significantly more effective than the other agents. Specifically, the similar agent will be most likely to reduce endorsement of gender and engineering stereotypes, increase perceived utility of engineering, increase reported interest in engineering-related fields, and increase reported self-efficacy in engineering-related fields. In addition, we hypothesized that the similar agent would be more likable and would be perceived as more persuasive than the other agents. However, it should be noted that Moreno and Flowerday (2006) found that students of color are more likely to choose same-ethnicity agents than White students. Thus, it was also possible that White women would prefer women but not distinguish so much on race.

II. Method

A. Participants

Participants for Experiment 1 included 80 female, African American undergraduate students enrolled in an introductory technology course who consented to participate (age $M = 22.75$, $SD = 5.77$). Experiment 2 included 39 female, White undergraduate students enrolled in an introductory technology course who consented to participate (age $M = 20.23$, $SD = 2.97$). The participants came from one of two southeastern universities and the college of education at the universities offered the courses for students majoring in various fields (e.g., biology, political sciences, math education, science education, and psychology).

B. Research Design and Independent Variables

Both studies employed a 2 (Agent gender: male vs. female) × 2 (Agent race: Black vs. White) between subjects factorial design. Participants were assigned to one of the four agent conditions. The agents were designed to be young (~25 years) and attractive (as manipulated by the agent's facial features) and varied in their gender and race. Pre-testing of the agents confirmed that participants perceived them as young and attractive and White or Black. The agents (see Figure 1) were created in Poser©.

Audio files of human female and male voices were synchronized with the agents using Mimic2Pro© to create lip-synching and emotional expressions. The voice was held constant with respect to tone and prosody for each agent gender. Several deictic gestures (e.g., pointing a finger) were also included. These gestures were identical for all agents. A fully integrated environment was created using Flash MX Professional©.

C. Dependent Variables

The five dependent variables were gender stereotypes, engineering stereotypes, utility, self-efficacy, and interest. The dependent variables were all measured using a 7-point, Likert-type scale and scored such that higher scores indicated a positive impact of the agent (Baylor and Plant, 2005). Three items were used for rejection of gender stereotypes about engineering (Experiment 1: α[1] = 0.82; Experiment 2: $\alpha = 0.82$; e.g., "Women can succeed in engineering careers."). Five items were used for engineering stereotyping (Experiment 1 $\alpha = 0.69$; Experiment 2: $\alpha = 0.69$; e.g., "Engineers are unemotional"). Seven items assessed the participants' beliefs about the utility of engineering (Experiment 1: $\alpha = 0.78$; Experiment 2: $\alpha = 0.74$; e.g., "I would have many good career opportunities if I were an engineering major"). Eight items assessed the participants' self-efficacy in engineering-related fields (Experiment 1: $\alpha = 0.86$; Experiment 2: $\alpha = 0.86$; e.g., "I believe I have the natural talent to excel as an engineering major"). Seven items assessed the participants' interest in taking engineering related classes (Experiment 1: $\alpha = 0.85$; Experiment 2: $\alpha = 0.90$; e.g., "I would like to have a career in an engineering related field").

In addition to assessing the participants' thoughts and feelings about engineering, we also measured the participants' perception of the agent and the message provided. Six items assessed the participants' perception of the agent as likeable (Experiment 1: $\alpha = 0.87$; Experiment 2: $\alpha = 0.89$; e.g., "The engineer who spoke to me was likeable") and six items assessed the participants' perception of the message as persuasive (Experiment 1: $\alpha = 0.85$; Experiment 2: $\alpha = 0.82$; e.g., "The information I heard convinced me that engineering is something I could succeed at").

D. Research Environment

The assigned agent (set in a coffee shop location) introduced him or herself and provided a twenty-minute narrative about four female engineers, followed by five benefits of engineering careers ("You'll have the power to make a difference in many ways!," "You'll make plenty of money and have job security!," "You'll be working with lots of interesting people!," "You can work in diverse environments and situations!," and "You'll get to create new things!") . This script was validated as effective in Baylor and Plant (2005) for increasing young women's interest in engineering from a pre- to post-test. Periodically, the participants interacted with the agent to continue the presentation (i.e., participants mouse-clicked the next topic to be addressed by the agent).

Figure 1. The four agents that were presented: female Black, female White, male Black, and male White.

E. Procedure

The experiment was conducted in a regularly scheduled classroom lab session where students accessed the online module through a Web-browser (see Figure 2 for a screen-shot). Following completion, participants answered the online post-survey questions. The exercise was incorporated into a regular class lecture and was required by the course and for which the participants received appropriate credit. Students had the choice whether to allow their data to be part of the study. Ethical procedures for human subjects and obtaining informed consent were properly followed.

III. Results

To determine the effects of agent race and gender, a series of 2 (Agent race: Black vs. White) × 2 (Agent gender: Male vs. Female) between-groups analyses of variance (ANOVAs) were performed on each of the key dependent variables: gender stereotypes, engineering stereotypes, utility, self-efficacy, and interest. In addition, to determine how the participants felt about the agent and how

[1]Reliabilities for each scale were calculated for the current sample.

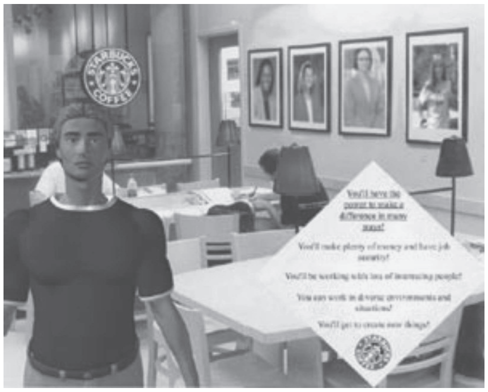

Figure 2. Sample screenshot.

Measure	White Agent Female (*N* = 23) M (SD)	White Agent Male (*N* = 18) M (SD)	Black Agent Female (*N* = 21) M (SD)	Black Agent Male (*N* = 18) M (SD)
Gender stereotypes	5.66^{a} (1.74)	5.94^{ab} (1.63)	6.65^{b} (0.72)	6.35^{ab} (0.97)
Engineering stereotypes	4.77^{a} (0.90)	5.11^{a} (1.14)	5.20^{a} (1.09)	4.82^{a} (0.85)
Utility	3.59^{a} (1.18)	4.22^{b} (0.89)	5.27^{c} (0.84)	4.17^{ab} (0.96)
Self-efficacy	3.30^{a} (1.13)	4.29^{bc} (1.27)	4.50^{c} (1.07)	3.60^{ab} (1.14)
Interest	2.90^{a} (1.19)	3.30^{a} (1.39)	4.26^{b} (1.19)	3.43^{a} (1.11)
Agent liking	4.76^{a} (1.51)	5.62^{b} (1.16)	5.73^{b} (0.87)	5.26^{ab} (1.05)
Message persuasiveness	3.89^{a} (1.00)	4.29^{ab} (1.51)	5.03^{b} (1.32)	4.27^{ab} (1.32)

Note. Means in a row with different superscripts significantly differed at $p < 0.05$. (For example, for gender stereotypes, White female differed from Black female but White and Black male conditions fell in between.)

Table 1. Scores for each dependant variable (Experiment 1).

persuasive the message was, 2 (Agent race: Black vs. White) × 2 (Agent gender: Male vs. Female) between-groups ANOVAs were performed for agent-liking and for message-persuasiveness (see Table 1 and 2 for all analyses). We had predicted that agents that were more similar to the participants in race and gender would be the most effective in changing the participants' beliefs about engineering.

A. Experiment 1 Results

The analysis for *gender stereotypes* revealed a significant main effect for agent race, $F(1,76) = 5.23, p < 0.05$. Participants who interacted with the Black agent were significantly more likely to reject gender stereotypes about women's ability to perform in engineering than those who interacted with the White agent. The analysis for *engineering stereotype* revealed no significant effects.

Measure	White Agent Female (*N* = 13) M (SD)	White Agent Male (*N* = 9) M (SD)	Black Agent Female (*N* = 10) M (SD)	Black Agent Male (*N* = 7) M (SD)
Gender stereotypes	6.79 (0.32)	6.33 (1.1)	6.63 (0.53)	6.19 (0.79)
Engineering stereotypes	5.44 (0.78)	5.28 (1.07)	4.88 (1.04)	4.57 (0.66)
Utility	4.20 (1.06)	4.57 (0.89)	3.84 (0.71)	3.59 (0.65)
Self-efficacy	3.44 (1.51)	2.98 (0.49)	4.01 (1.48)	3.19 (1.52)
Interest	3.00 (1.26)	2.95 (1.19)	2.37 (1.04)	1.83 (0.46)
Agent liking	5.43 (1.12)	5.38 (1.05)	5.31 (0.60)	6.09 (1.08)
Message persuasiveness	4.01 (1.39)	4.07 (1.15)	3.60 (0.85)	4.35 (0.94)

Table 2. Scores for each dependent variable (Experiment 2).

The analysis for *utility* revealed a significant main effect for agent race, $F(1,76) = 13.51, p < 0.001$. Participants who interacted with the Black agent were significantly more likely to believe that there is high utility for engineering than those who interacted with the White agent. In addition, the analysis also revealed an interaction between agent race and agent gender, $F(1,76) = 15.12, p < 0.001$ (see Figure 3). Post-hoc tests revealed that the female Black agent was significantly more influential than all the other agents, p's < 0.002. It is also worth noting that although when the participants interacted with a Black agent, the female agent was significantly more influential than the male agent ($p < 0.002$), when they interacted with a White agent, the male agent was significantly more influential than the female agent ($p < 0.05$).

The analysis for *self-efficacy* revealed a significant interaction between agent race and agent gender, $F(1,76) = 13.26, p < 0.001$. Post-hoc tests revealed that if the participants interacted with a Black agent, the participants who interacted with the female agent were significantly more likely to report high self-efficacy in engineering-related fields than those who interacted with the male agent ($p < 0.05$). In contrast, when the participants interacted with a White agent, the participants who interacted with the male agent were significantly more likely to report high self-efficacy in engineering-related fields than those who interacted with the female agent ($p < 0.01$).

The analysis for *interest* revealed a significant main effect for agent race, $F(1,76) = 7.35, p < 0.01$. Participants who interacted with the Black agent were significantly more likely to report high interest in engineering-related fields than those who interacted with the White agent. In addition, the analysis revealed an interaction between agent race and agent gender, $F(1,76) = 4.93, p < 0.05$ (see Figure 4). Post-hoc tests revealed the female Black agent was significantly more influential than all the other agents (p's < 0.05). The other three agent conditions did not differ from each other,

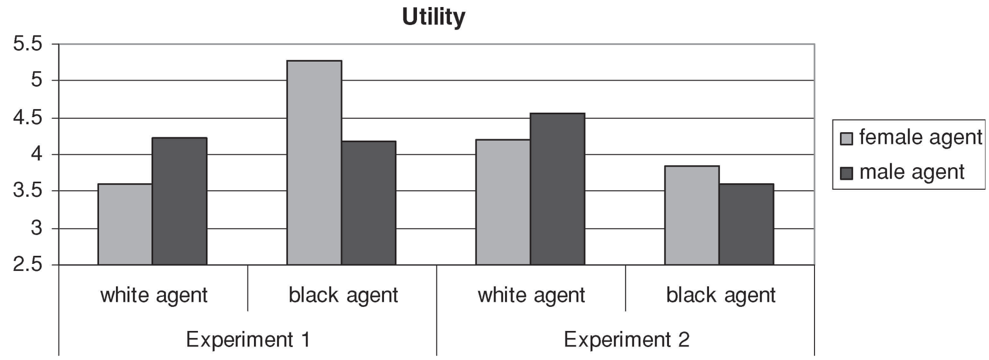

Figure 3. Participants' beliefs regarding the utility for engineering across conditions and experiments.

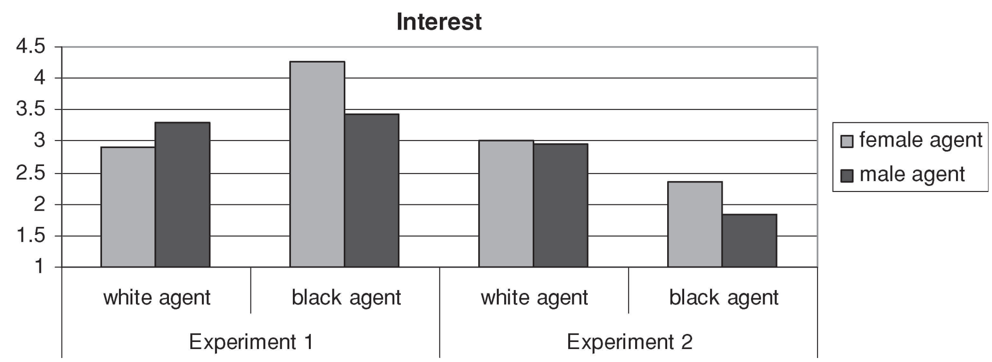

Figure 4. Participants interest in engineering across conditions and experiments.

although once again, the White female was the least effective (though not significantly).

The analysis for *agent-liking* revealed a significant interaction between agent race and agent gender, $F(1,76) = 15.12, p < 0.0001$. Post-hoc tests revealed that if the participants interacted with a Black agent, the female agent was rated significantly more likable than the male agent ($p < 0.002$), whereas if the participants interacted with a White agent, the male agent was rated significantly more likeable than the female agent ($p < 0.05$).

Finally, the analysis for *message persuasiveness* revealed an interaction between agent race and agent gender, $F(1,76) = 4.05$, $p < 0.05$. Post-hoc tests revealed that the message was rated as significantly more persuasive when presented by the female Black agent as compared to the female White agent ($p < 0.01$) and marginally more persuasive than when presented by the male Black agent ($p = 0.07$) and the male White agent ($p = 0.08$).

B. Experiment 2 Results

The purpose of Experiment 2 was to examine whether Experiment 1 findings would be replicated when the participants were White female students. The analysis for *gender stereotypes* revealed a trend towards significance for agent gender, $F(1,35) = 3.84, p < 0.06$. Participants who interacted with the female agent were marginally less likely to endorse negative gender stereotypes than those who interacted with the male agent. The analysis for *engineering stereotype* revealed a significant main effect for agent race, $F(1,35) = 4.57$, $p < 0.05$. Participants who interacted with the White agent were significantly less likely to endorse engineering stereotypes than those who interacted with the Black agent.

The analysis for *utility* revealed a significant main effect for agent race, $F(1,35) = 5.43$, $p < 0.05$ (see Figure 3). Participants who interacted with the White agent were significantly more likely to believe that there is high utility for engineering than those who interacted with the Black agent.

The analysis for *interest* revealed a significant main effect for agent race, $F(1,35) = 5.92$, $p < 0.05$ (see Figure 4). Participants who interacted with the White agent were significantly more likely to report high interest in engineering-related fields than those who interacted with the Black agent.

The analysis for *self-efficacy*, *agent-liking*, and *message persuasion* did not reveal significant effects.

IV. Discussion

The current work explored an approach to encourage young women to pursue careers in engineering by targeting women's negative beliefs about engineering and their lack of confidence in their own abilities using computer-based anthropomorphic social models. Of particular interest was the impact of the model's race and gender for its effectiveness and whether matching the race and gender of the participant to the computer-based social model increased the efficacy of this approach. Drawing from the literature on social models (Bandura, 1986; Mussweiler, 2003; Schunk, Hanson, and Cox, 1987; Wood and Bandura, 1989), we had predicted that the agents that were more similar to the participants in race and gender would be the most effective in changing the participants' beliefs about engineering.

In accordance with our hypothesis, across both studies we found that race influenced the efficacy of the agent for several of our key outcome measures. In both of the experiments, we found that participants who interacted with an agent that matched their race, whether Black or White, responded more positively to engineering than those who interacted with an agent of a different race. Specifically, we found that both the White and the Black participants who interacted with an agent that matched their race were significantly more likely to believe that there is high utility for engineering and were significantly more likely to report high interest in engineering-related fields than those who interacted with an agent who did not match their race. In addition, there were some effects of agent race for stereotypic beliefs. For the White participants, those who interacted with a White agent were significantly less likely to endorse *engineering stereotypes* than those who interacted with a Black agent. For the Black participants, those who interacted with a Black agent were significantly less likely to endorse *gender stereotypes* than those who interacted with a White agent.

In our previous study (Rosenberg-Kima et al., 2008), we found that the female agents were the most effective for influencing young women's stereotypes about engineering. Although it did not reach significance, we found a similar effect on gender stereotypes for the White participants. Specifically, participants who interacted with the female agent were marginally less likely to endorse gender stereotypes than those who interacted with the male agent. It is possible that we did not obtain a significant main effect for gender in this study due to the fact that some of the female agents differed from the participants in terms of their race, and therefore, may not have been perceived as similar to the participant. In our previous study, the female agents were always White as were most of the participants.

In addition to the main effects, in Experiment 1 we found an interesting reccurring interaction between the agent's race and the agent's gender. Black participants who interacted with the female, Black agent were significantly more likely to report high utility for engineering and high interest in engineering than participants who interacted with all the other agents. In addition, if the participants interacted with a Black agent, those who interacted with the female agent were significantly more likely to report high utility for engineering, high self-efficacy in engineering-related fields, and to rate the agent as more likeable than those who interacted with the male agent. In contrast, if the participants interacted with a White agent, the participants who interacted with the male agent were significantly more likely to report high utility for engineering, high self-efficacy in engineering-related fields, and to rate the agent as more likeable than those who interacted with the female agent. To summarize, for the Black participants, if the agent was Black, then the female was more effective, whereas if the agent was White, then the male was more effective for several of the key outcome measures.

The fact that the White male agent was more effective than the White female agent for the Black participants was surprising because the White female agents had their gender in common with the Black female participants, and based on the similarity hypothesis, people are more persuaded by social models that are similar to them (e.g., Bandura, 1986; Mussweiler, 2003; Schunk, 1987; Wood and Bandura, 1989). One possible explanation for these unpredicted results is that people are also persuaded by those whom they perceive as experts (e.g., Chaiken and Maheswaran, 1994; Debono and Harnish, 1988; Hovland and Weiss, 1951). Because White men tend to outnumber Black men and women in the field of engineering, White male agents may more resemble the prototypical engineer. As a result, they may have been more influential than the White female agent for the Black participants. This explanation may also account for the contradicting findings we received between the two experiments.

Unlike Experiment 1, in Experiment 2 we did not observe an interaction between gender and race for the White participants. The White participants were more influenced by the race of the agents than by the gender of the agents, and we only observed a main effect for race. Specifically, those who interacted with a White agent were significantly less likely to endorse engineering stereotypes, were significantly more likely to believe that there is high utility for engineering, and were significantly more likely to report high interest in engineering-related fields than those who interacted with a Black agent. It is possible that for the White participants, similar to the Black participants, the two most influential agents were the White female, who was the most similar to the participants, and the White male who was the most similar to a prototypical engineer. This could explain the fact that we did not find an interaction between race and gender or a main effect of gender for the White participants, but instead found only a main effect of race. Alternatively, it is also possible that White female students relate more strongly to being White than to being female, which could account for the lack of interaction with race.

There was, however, a consistent finding across the studies that the agent's race had a significant influence on both the White and the Black participants. In their previous study, Moreno and Flowerday (2006) found that when given the opportunity to choose the ethnicity of an animated pedagogical agent, students of color chose significantly more same-ethnicity agents than agents of another ethnicity. This was not the case for White students who did not tend to pick White agents significantly more than other agents. In contrast to this previous study, we found that when the participants are randomly assigned to animated agents, the race of the agent makes a difference regardless of the participants' ethnicity. However, our work was not examining possible effects of choosing an agent and the previous work did not examine the efficacy of randomly assigned agents.

V. Limitations, Implications, and Future Directions

A limitation to this study is the lack of a pre-test control for the students' attitudes towards engineering. Yet, a pre-test in this case would have exposed the participants to the content and purpose of the persuasive message, thereby possibly negating the purpose of the study (e.g., through expectancy or demand effects). By randomly assigning participants to experimental conditions within each experiment, we were able to examine differences between the experimental groups without cueing participants to the content of the persuasive message. In addition, due to the lack of pre-test control for the students' attitudes towards engineering, it is difficult to draw conclusions about the relative efficacy of our agents across the two experiments. That is, because we did not assess the baseline attitudes for each population, it was not possible to determine whether overall one group (e.g., the White participants) changed their attitudes to a larger degree than the other did. Nonetheless, it is still possible to compare the efficacy of the various agents for each of the populations.

Another limitation to this study is the fact that our measures were taken immediately after the intervention. The majority of studies in the field of computer-based agents focus on short term effects of the agents. Nevertheless, a few studies have examined the possibility of using computer-based agents on a more long-term basis and indicate that they may be effective for up to four weeks (Bickmore and Picard, 2005). Further research looking into decisions to pursue engineering majors and careers as well as retention level is needed to determine whether these approaches can have long-term effects. Nonetheless, the short-term effect of the agent is still of value. For example, if the agent is used a short time prior to selection of major, its shot-term effect may be enough to increase the enrollment level to engineering. Subsequent interventions may then be needed to raise retention level, increase graduate school enrolment, and so on.

Yet another possible limitation of this study is the fact that there was a difference in the participants' average age between the two experiments. Participants in the first experiment were two years older on average and had more variability in their ages. The age difference between the populations may have an impact on the results. However, we believe that the differences in the results between the experimental groups are better explained by their race rather then their age. Furthermore, the age difference should not affect the results within each of the experiments in which the groups were similar in their age.

An important question for future research is: what characteristics of a social model, in general, and an animated pedagogical agent in particular most influence the students' sense of similarity to the agent and the efficacy of the agent? For example, in this study we found that the race of the agent was more important than the agent's gender for changing the participants' attitudes, implying that race contributes to a sense of similarity more than gender. However, for our Black participants, it was the combination of race and gender that was important. In a previous study (Rosenberg-Kima et al., 2008) we found that young and "cool" agents were the most effective for influencing the women's self-efficacy and interest in the field of engineering, and female agents were the most effective for influencing their stereotypes about engineering. Therefore, in this study we purposely used agents that were young and "cool." In future work, it will be informative to explore the interactive effects of a range of agent characteristics for persuading people. Finally, in this study we had only two ethnic groups. Future research should target a larger range of ethnic groups as well as people who vary along other sociological characteristics such as disabilities, socioeconomic background, and so on.

Our hope is that the findings from the current work regarding the efficacy of similar agent models can be used to decrease the current under-representation of women and minorities in engineering (MentorNet, 2004). The availability of role models is a key factor influencing women and minorities' interest in engineering (Seymour and Hewitt, 1997; Trenor, Yu, Waight, and Sha, 2008). Thus, using interface agents instead of relying on human models may be a more feasible but still effective way to serve the needs of underrepresented students. In addition, because interface agents may be used starting from an early age to change young women's attitudes and self-efficacy about engineering and related fields, they may encourage greater persistence in the field (Besterfield-Sacre, Moreno, Shuman, and Atman, 2001; Eccles, 1987, 1994; Marra et al., 2009; Seymour and Hewitt, 1997). If young women can be caught early and their counter-productive beliefs disabused, it may have an impact on the early decisions they make (e.g., what classes to take) that could have implications for their ability and likelihood to pursue engineering in the future. At the college and graduate level, interface agents may help to increase the retention level of women in engineering fields. We believe that targeting women in this way throughout their education could contribute to the growth and inclusiveness of fields such as engineering.

More practically, we believe that interface agents are a tool that is easily integrated into the classroom and used by educators. Current technologies allow for relatively easy implementation of such an interface agent that is tailored to fit various students as part of coursework. Such an agent can act as a teaching tool with incorporated persuasive message points throughout the lesson plans. Thus, all the students will listen to the same lesson, but the characteristics of the agent will maximize its effect across the students. Developing such an agent could be especially effective if it would be done on a larger scale (e.g., a university recruiting effort that can be sent throughout the country), thus, low cost development of several interface agents, can widely benefit minority students by providing them, perhaps for the first time, with access to a social model that is similar to them.

Acknowledgment

This work was supported by the National Science Foundation, Grant HRD-0429647 awarded to the second and fourth authors.
Send correspondence regarding this manuscript to E. Ashby Plant, Department of Psychology, Florida State University, P.O. Box 3064301, Tallahassee, FL 32306-4301. Electronic mail may be sent to plant@psy.fsu.edu.

References

Adams, J. 2001. Are traditional female stereotypes extinct at Georgia Tech? *The Technique* October 26: F1–F3.

Atkinson, R.K. 2002. Optimizing learning from examples using animated pedagogical agents. *Journal of Educational Psychology* 94 (2): 416–27.

Bandura, A. 1977. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review* 84 (2): 191–215.

Bandura, A. 1986. *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. 1997. *Self-efficacy: The exercise of control*. New York: W.H. Freeman and Company.

Bandura, A., and D.H. Schunk. 1981. Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology* 41 (3): 586–98.

Baylor, A.L. 2002. Expanding preservice teachers' metacognitive awareness of instructional planning through pedagogical agents. *Educational Technology, Research & Development* 50 (2): 5–22.

Baylor, A.L. 2005. *The impact of pedagogical agent image on affective outcomes*. Paper presented at the International Conference on Intelligent User Interfaces. San Diego, CA.

Baylor, A.L., and S. Kim. 2009. Designing nonverbal communication for pedagogical agents: When less is more. *Computers in Human Behavior* 25 (2): 450–57.

Baylor, A.L., and Y. Kim. 2005. Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education* 15 (1): 95–115.

Baylor, A.L., and E.A. Plant. 2005. Pedagogical agents as social models for engineering: The influence of appearance on female choice. In *Artificial intelligence in education: Supporting Learning through intelligent and socially informed technology*, eds. C.K. Looi, G. McCalla, B. Bredeweg, and J. Breuker, 65–72. Amsterdam, The Netherlands: IOS Press.

Besterfield-Sacre, M.B., M. Moreno, L.J. Shuman, and C.J. Atman. 2001. Gender and ethnicity differences in freshman engineering student attitudes: A cross-institutional study. *Journal of Engineering Education* 90 (4): 477–90.

Bickmore, T.W., and R.W. Picard. 2005. Establishing and maintaining long-term human-computer relationships. *ACM Transactions on Computer-Human Interaction* 12 (2): 293–327.

Byrne, E.M. 1993. *Women and science: The snark syndrome*. London: Falmer Press.

Chaiken, S. 1979. Communicator physical attractiveness and persuasion. *Journal of Personality and Social Psychology* 37: 1387–97.

Chaiken, S., and D. Maheswaran. 1994. Heuristic processing can bias systematic processing: Effects of source credibility, argument ambiguity, and task importance on attitude judgment. *Journal of Personality and Social Psychology* 66 (3): 460–73.

Debono, K.G., and R.J. Harnish. 1988. Source expertise, source attractiveness, and the processing of persuasive information—a functional-approach. *Journal of Personality and Social Psychology* 55 (4): 541–46.

Eccles, J.S. 1987. Gender roles and women's achievement-related decisions. *Psychology of Women Quarterly* 11 (2): 135–72.

Eccles, J.S. 1994. Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement related choices. *Psychology of Women Quarterly* 18 (4): 585–609.

Elaine, L.C., and L.R. Philip. 2007. *Women in the labor force: A databook*. (No. 1002). Washington, DC: U.S. Department of Labor.

Etzkowitz, H., C. Kemelgor, and B. Uzzi. 2000. *Athena unbound: The advancement of women in science and technology*. Cambridge: Cambridge University Press.

Goethals, G.R., and R.E. Nelson. 1973. Similarity in the influence process: The belief-value distinction. *Journal of Personality and Social Psychology* 25 (1): 117–22.

Goodman, I.F., C.M. Cunningham, C. Lachapelle, M. Thompson, K. Bittinger, R.T. Brennan, M. Delci. 2002. *Final report of the women's experiences in college engineering project*. Cambridge, MA: Goodman Research Group, Inc.

Hersh, M. 2000. The changing position of women in engineering worldwide. *IEEE Transactions on Engineering Management* 47 (3): 345–59.

Heyman, G.D., B. Martyna, and S. Bhatia. 2002. Gender and achievement related beliefs among engineering students. *Journal of Women and Minorities in Science and Engineering* 8 (1): 41–52.

Hovland, C.I., and W. Weiss. 1951. The influence of source credibility on communication effectiveness. *Public Opinion Quarterly* 15: 635–50.

Hughes, W.J. 2002. Gender attributions of science and academic attributes: An examination of undergraduate science, mathematics, and technology majors. *Journal of Women and Minorities in Science and Engineering* 8 (1): 53–65.

Hutchison, M.A., D.K. Follman, and M. Sumpter. 2006. Factors influencing the self-efficacy beliefs of first-year engineering students. *Journal of Engineering Education* 95 (1): 39–47.

Ingram, S., S. Bruning, and I. Mikawoz. 2009. Career and mentor satisfaction among Canadian engineers: Are there differences based on gender and company-specific undergraduate work experiences? *Journal of Engineering Education* 98 (2): 131–44.

Johnson, W.L., J.W. Rickel, and J.C. Lester. 2000. Animated pedagogical agents: Face-to-face interaction in interactive learning environments. *International Journal of Artificial Intelligence in Education* 11: 47–78.

Kram, K. 1985. *Mentoring at work: Developmental relationships in organizational life*. Glenview, IL: Scott Foresman and Company.

Lippa, R. 1998. Gender-related differences and the structure of vocational interests: The importance of the people-things dimension. *Journal of Personality and Social Psychology* 74 (4): 996–1009.

Marra, R.M., K.A. Rodgers, D. Shen, and B. Bogue. 2009. Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education* 98 (1): 27–38.

Marx, D.M., and P.A. Goff. 2005. Clearing the air: The effect of experimenter race on target's test performance and subjective experience. *British Journal of Social Psychology* 44 (4): 645–57.

McIntyer, B., R.M. Paulson, and C.G. Lord. 2003. Alleviating women's mathematics stereotype threat through salience of group achievements. *Journal of Experimental Social Psychology* 39 (1): 83–90.

Mcllwee, J.S., and J.G. Robinson. 1992. *Women in engineering: Gender, power, and workplace culture*. Albany: State University of New York Press.

MentorNet. 2004. *E-mentoring for women of color in engineering and science final report to the engineering information foundation*. http://www.mentornet.net/files/WomenofColorFinalReportMay2004.pdf (last accessed, October 2009).

Moreno, R., and T. Flowerday. 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.

Moreno, R., R.E. Mayer, H.A. Spires, and J.C. Lester. 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 (2): 177–213.

Mussweiler, T. 2003. Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review* 110 (3): 472–89.

Nass, C., and K.N. Lee. 2001. Does computer-synthesized speech manifest personality? Experimental tests of recognition, similarity-attraction, and consistency-attraction. *Journal of Experimental Psychology-Applied* 7 (3): 171–81.

Nass, C., and Y. Moon. 2000. Machines and mindlessness: Social responses to computers. *Journal of Social Issues* 56 (1): 81–103.

Nass, C., Y. Moon, B.J. Fogg, B. Reeves, and D.C. Dryer. 1995. Can computer personalities be human personalities. *International Journal of Human-Computer Studies* 43 (2): 223–39.

Nass, C., Y. Moon, and N. Green. 1997. Are machines gender neutral? Gender-stereotypic responses to computers with voices. *Journal of Applied Social Psychology* 27 (10): 864–76.

National Science Foundation. 2000. *Women, minorities, and persons with disabilities in science and engineering: 2000*. NSF 00-327. http://www.nsf.gov/statistics/nsf00327 (last accessed, October 2009).

National Science Foundation. 2003. *Women, minorities and persons with disabilities in science and engineering: 2002*. 03-312. http://www.nsf.gov/statistics/nsf03312 (last accessed, October 2009).

National Science Foundation. 2008. *Science and engineering indicators: 2008*. http://www.nsf.gov/statistics/seind08 (last accessed, October 2009).

Reeves, B., and C. Nass. 1996. *The media equation*. New York: Cambridge University Press.

Rosenberg-Kima, R.B., A.L. Baylor, E.A. Plant, and C.E. Doerr. 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): 2741–56.

Schunk, D.H. 1987. Peer models and children's behavioral change. *Review of Educational Research* 57 (2) 149–74.

Schunk, D.H., A.R. Hanson, and P.D. Cox. 1987. Peer-model attributes and children's achievement behaviors. *Journal of Educational Psychology* 79 (1): 54–61.

Seymour, E., and N.M. Hewitt. 1997. *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Shashaani, L. 1997. Gender differences in computer attitudes and use among college students. *Journal of Educational Computing Research* 16 (1): 37–51.

Trenor, J.M., S.L. Yu, C.L. Waight. K.S. Zerda, and T. Sha. 2008. The relations of ethnicity to female engineering students' educational experiences and college and career plans in an ethnically diverse learning environment. *Journal of Engineering Education* 97 (4): 449–65.

Wilder, D.A. 1990. Some determinants of the persuasive power of in-groups and out-groups: Organization of information and attribution of independence. *Journal of Personality and Social Psychology* 59 (6): 1202–13.

Wood, R., and A. Bandura. 1989. Impact of conceptions of ability on self-regulatory mechanisms and complex decision making. *Journal of Personality and Social Psychology* 56 (3): 407–15.

Authors' Biographies

Rinat B. Rosenberg-Kima is a doctoral candidate at Florida State University, pursuing a Ph.D. in Educational Psychology and Learning Systems under the direction of Dr. Amy L. Baylor. She received her B.S. degree in Computer Sciences and M.A. degree in Psychology from Tel-Aviv University, Israel. She has taught several courses at the computer sciences department at the Open University of Israel and developed educational software in various settings including leading the technology team at the Center for Research on Innovative Technologies for Learning (RITL). Her research interest includes social computing as well as complex learning.

Address: Florida State University, 3205D Stone Building, Tallahassee FL 32306-4450; telephone: (+1) 850.644.6885; e-mail: rr05@fsu.edu.

Dr. E. Ashby Plant is associate professor of Social Psychology at Florida State University. She received her Ph.D. from the University of Wisconsin—Madison in 2000. Her research explores prejudice and stereotyping with a focus on the prejudice reduction process. Recent work examines the factors that influence the course and quality of interracial interactions, approaches to encouraging young women and minority group members to pursue nontraditional academic careers, and the implications of race for responses to criminal suspects. Her research has been supported by the National Institute of Health, the National Science Foundation, and the American Psychological Foundation.

Address: Florida State University, Department of Psychology, 1107 W. Call Street, Tallahassee, FL 32306-4301; telephone: (+1) 850.644.5533; e-mail: plant@psy.fsu.edu.

Celeste Doerr is a graduate student at Florida State University. She earned a M.S. degree in Social Psychology from Florida State University in 2007. Her research focuses on stereotypes and prejudice, with specific emphasis on factors that support attitude change. She is currently working toward her doctoral degree under the direction of Dr. E. Ashby Plant.

Address: Florida State University, Department of Psychology, 1107 W. Call Street, Tallahassee, FL 32306-4301; e-mail: doerr@psy.fsu.edu.

Dr. Amy L. Baylor is on leave from FSU, where she is Associate Professor of Instructional Systems and Information Technology. Her research focuses on social computing and the design of anthropomorphic interface agents to promote learning and motivational outcomes. She has served as the principal investigator for over $1.5 million of federal research grants, and is the founder/director of the Center for Research on Innovative Technologies for Learning (RITL), http://ritl.fsu.edu.

Address: Florida State University, 3205D Stone Building, Tallahassee FL 32306; telephone (+1) 850.644.8789; e-mail: abaylor@fsu.edu.