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Interface agents as social models for female students: The effects of agent visual presence and appearance on female students' attitudes and beliefs

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ABSTRACT

The current work investigates the use of interface agents as anthropomorphic social models to influence young women's negative beliefs and low self-efficacy regarding engineering. Experiment 1 focused on the impact of agent model visual presence vs. voice alone for changing the women's beliefs. Based on literature on human social models we hypothesized that the visual presence of the interface agent would result in more positive attitudes toward engineering and greater self-efficacy than the presence of a human voice alone. Experiment 2 focused on the impact of model appearance-related characteristics for changing the women's beliefs. Previous work with human social models suggests that people are more persuaded by models that are similar to them. Therefore, models that were young, female, and "cool" were predicted to be more effective in influencing young women's attitudes. In accordance with our hypothesis, results revealed that participants who interacted with the visible agents reported significantly greater utility for engineering, greater self-efficacy, and greater interest in engineering-related fields than those who interacted with a human voice. In addition, the agent models that were similar to the young women tended to be the most effective for positively influencing the women's stereotypes and self-efficacy.

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1. Introduction

Even though women have achieved increasing inclusion and success in professions that were formerly occupied primarily by men, they remain under-represented in the field of engineering (Goodman et al., 2002). For example, only 8.5% of all professional engineers are women, although women constitute 56.8% of the total workforce (Goodman et al., 2002). Furthermore, according to a recent national science foundation (NSF) report (2003), 64% of all psychologists are women compared to 10% of physicist/astronomers and engineers. This absence of women in engineering is also evident at the postsecondary level. Even though women are more likely than men to attend college, women account for only 20% of total undergraduate enrollment in engineering programs (NSF, 2003). Women's under-representation in engineering may result in part from female students' negative beliefs regarding engineering as a field and their ability to succeed at engineering (Shashaani, 1997).

One potential approach to encourage women to pursue engineering would be to provide them access to human social models who could help to change their unproductive beliefs and ideas about engineering. However, the use of social models requires extensive time from already busy engineers; in addition, the engineers available to be social models may not be an ideal match for the young women. Innovations in technology may provide a promising alternative to the use of human social models. Previous work indicates that computer-based, anthropomorphic interface agents can be effective learning and persuasive tools (Atkinson, 2002; Baylor & Plant, 2005; Nass, Moon, Fogg, Reeves, & Dryer, 1995). Interface agents are anthropomorphic, 3D-animated computer characters that provide teaching or mentoring within a computer-based learning environment. Interface agents have been found to increase young women's interest in and self-confidence regarding engineering (Baylor & Plant, 2005). To date, however, it is unclear what aspects of these computer-generated interface agents are important for their efficacy (e.g., message, visual appearance).

The current work explores an approach to encourage young women to pursue careers in engineering. In particular, we investigated the role of anthropomorphic interface agents' visual presence and appearance-related characteristics in influencing female students' beliefs and attitudes toward engineering. Experiment 1 focused on the impact of agent models' visual presence vs. voice alone for changing the women's beliefs and attitudes, whereas Experiment 2 focused on the impact of agent models' appearance-related characteristics (gender, age, and "coolness") for changing women's beliefs and attitudes.

1.1. Interface agents as persuasive tools

According to Bandura (1997), much of our learning derives from vicarious experience. 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. Social models can also influence people's attitudes (Goethals & Nelson, 1973). In particular, observing a social model that is similar to oneself perform a behavior, provides information regarding their likely self-efficacy for similar behaviors (Bandura & Schunk, 1981). Not all potential social models are similarly effective, however. People tend to learn from similar others, who either resemble them closely or who match their ideals of themselves (Bandura, 1986; Mussweiler, 2003; Schunk, Hanson, & Cox, 1987; Wood & Bandura, 1989).

Thus, one way to change young women's attitudes toward engineering might be to provide them with a young, female engineer social model. Even though a human social model may provide a high level of interactivity and response, providing students with young, female social models in math, the hard sciences, and engineering may be problematic because it would contribute to the already burdensome workloads faced by women in nontraditional fields (Hersh, 2000). Moreover, different students may benefit from different types of social models (e.g., models that differ in ethnicity, age, gender, etc.). Therefore, it would be useful to find alternative mechanisms for providing a social model that is both easily accessible for a large population of students and that can be personalized depending on the individual needs of the students.

Interface agents can potentially serve as simulated social models to impact beliefs and attitudes. Recent empirical evidence indicates that interface agents can positively influence young women's interest, motivation, and even self-efficacy regarding engineering (Baylor & Plant, 2005). In Baylor and Plant (2005), seventy-nine female undergraduate students selected one of sixteen interface agents (differing by appearance in four aspects (age, gender, attractiveness, ''coolness'')) from which they most preferred to learn about engineering. Interestingly, students tended to select to learn from the stereotypical engineers (those that were male and attractive, but uncool). After interacting with the chosen agent for approximately 15 min and receiving a persuasive message about engineering, it was revealed that the young women had more positive math-related beliefs. Specifically, the women reported more positive math and science related beliefs compared to their attitudes at the beginning of the semester and compared to a group of women who did not interact with an agent. Further, among the women who viewed an agent, the older version of the agent had a stronger positive influence on their math-related beliefs than the younger agent.

Yet, here, and in other related research, students do not necessarily ''choose'' to learn from the agent that would be most beneficial for them (Baylor, 2005; Baylor & Kim, 2003; Baylor, Shen, & Huang, 2003). Thus, the next step from this preliminary study was to experimentally evaluate the impact of agent visual presence (vs. voice-only) as well as the optimal appearance for the agent model.

Extensive research has demonstrated that people tend to apply human social rules (e.g., engage in social behavior such as politeness and reciprocity towards computers) to computer technologies (e.g., Nass & Lee, 2001; Nass & Moon, 2000; Nass et al., 1995; Reeves & Nass, 1996). In a series of studies, Nass and his colleagues have shown that individuals consistently applied social rules and expectations to computers (Nass & Moon, 2000). Nass et al. (1995) demonstrated how people's responses to a computer personality resemble responses to real, human personalities. Specifically, they found that participants correctly identified the computer's personality type (dominant vs. submissive) and preferred and were more satisfied by interacting with a computer that matched their own personalities. They additionally demonstrated that individuals apply gender stereotypes to computers (Nass, Moon, & Green, 1997), ethnically identify with computer agents, and exhibit social behaviors toward computers (Nass & Moon, 2000).

There is also evidence that young women are particularly influenced by the communication and relational aspect of agents and may be more influenced by them than males (Baylor, 2002, 2005). In other domains, including instructional planning, computer literacy, and ethics, agent models have been found to enhance student self-efficacy (see Baylor, 2005). Therefore, interface agents, as simulated social models, may be particularly helpful in affecting young women's attitudes and self-efficacy with respect to engineering. However, it remains to be determined what characteristics of interface agents render them effective.

1.2. The impact of animated interface agents' voice and visual presence

According to social agency theory (Mayer, Sobko, & Mautone, 2003), social cues in a multimedia message (e.g., on-screen agent with human voice (Atkinson, Mayer, & Merrill, 2005)) lead learners to approach computerized learning contexts as interpersonal, conversational contexts. Once learners interpret their multimedia experience as social, the rules of human-to-human communication (Reeves & Nass, 1996) apply. Thus, similar to a human social partner, a computerized social partner encourages the learner to make sense of the material by increasing the learner's level of engagement (Atkinson et al., 2005; Mayer, Sobko et al., 2003).

In accordance with social agency theory, several studies have found evidence for the importance of the speaker's voice. For example, learners who received a narrated animation performed better on a learning transfer test when the interface agent had a standard accent compared to foreign accent and when the agent's voice was human rather than machine synthesized (Mayer, Sobko et al., 2003). Likewise, Atkinson et al. (2005) found that learners rated the agent with whom they worked more positively when the animated agent had a human voice compared to machine-synthesized voice.

In addition, Sproull, Subramani, Kiesler, Walker, and Waters (1996) found that people respond differently to a talking-face display compared to text-only display. That is, people were more likely to attribute personality attributes to the faces, had higher arousal when viewing the face (with higher levels of arousal defined by less relaxed and less confident), and presented themselves in a more positive light when interacting with the talking-face display compared to the text-only display.

While there is well documented research showing that an animated agent can be more effective than no agent at all (e.g., Baylor & Plant, 2005) or compared to text-only (e.g., Atkinson, 2002; Moreno, Mayer, Spires, & Lester, 2001; Sproull et al., 1996), it is not clear whether the voice is the most important feature of the interface agent. In particular, research findings are inconsistent as to whether an interface agent will result in higher levels of learning and greater change of attitudes than simply hearing the communicative message (i.e., voice-only) within the same computer-based environment. For example, with respect to learning outcomes, Atkinson (2002) found that participants who were exposed to the agent in combination with narrated instructions demonstrated better learning than did participants who were exposed to voice-only. These results suggest that the dual mode of presentation enhances learning outcomes in a multimedia learning environment (Atkinson, 2002; Mayer, 1997). In contrast, Moreno et al. (2001) and Mayer, Sobko et al. (2003) found that the visual presence of the agent was no more effective than a voice-only condition, suggesting that students' participation and communication modality (auditory rather than visual) may be the only factors that account for the deep understanding of an agent-based computer lesson (Moreno et al., 2001). A possible explanation for the difference between the two studies is that while Atkinson (2002) used an example-based learning environment, Moreno et al. (2001) used a discovery-based learning environment that might have required more cognitive resources (i.e., higher cognitive load). This may imply that a visual agent is more effective when cognitive load is lower. In addition, the visual agent in Atkinson (2002) provided additional information in the form of gestures that were relevant for understanding the examples.

Whereas results regarding agent presence on learning and performance outcomes are mixed, to our knowledge there is no research that has investigated the effect of agent presence for influencing *attitudes*. While cognitive load considerations may influence whether or not it is important to have an agent present in the learning domain, those considerations may not be as important when trying to influence attitudes. Furthermore, regarding attitude change, there is evidence that people are more likely to be affected by a similar other when an attitudinal, value-related issue is the object of influence (Goethals & Nelson, 1973). Therefore, a visual representation of an agent that is similar to the participant may be important for changing attitudes.

In order to examine these issues, the current work compared the effectiveness of a voice-only presentation to a presentation in which an agent was visually present. We hypothesized that a visually present interface agent would result in more positive attitudes and beliefs among our female participants.

1.3. Stereotypes and self-efficacy regarding engineering-related fields

In order to effectively influence women's beliefs and attitudes regarding engineering, it is important to understand which attitudes are most unproductive for women. Women's under-representation in engineering and related fields may result in part from the stereotypes about the people in these fields. Engineering and scientific fields are generally stereotyped as physically challenging, unfeminine, and aggressive (Adams, 2001). Additionally, the current under-representation of women in engineering may foster the impression that engineering is an atypical career for women (Byrne, 1993). Thus, awareness of 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. Self-efficacy refers to the belief that one is competent to meet situational demands (e.g., Bandura, 1977; Wood & 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). Additionally, female students tend to believe that math and engineering aptitudes are fixed abilities, thus attributing failure or success to stable factors (Heyman, Martyna, & Bhatia, 2002). Therefore, in order to increase young women's interest in engineering, it will be important to target their stereotypes and negative beliefs about engineering as a field and their self-efficacy for engineering-related domains.

1.4. The impact of agent characteristics

The current work is guided by the principle that, because people apply human social rules to human–computer interactions, social-learning rules should apply to people's interactions with anthropomorphic interface agents. Given a visibly present agent, research in social psychology (e.g., Bandura, 1997; Chaiken, 1979; McIntyer, Paulson, & Lord, 2003) suggests that the agent's physical appearance would be important in determining how persuasive a social model is for influencing young women's engineering-related beliefs. In general, people are more persuaded by social models that are similar to them or similar to how they would like to be (e.g., Bandura, 1986; Mussweiler, 2003; Schunk, 1987; Wood & Bandura, 1989). Similar others also provide information to observers about whether or not tasks are behaviorally appropriate for them (Schunk, 1987). Baylor and Plant (2005) found that undergraduate women indicated that they were similar to and would like to resemble agents that were pre-tested to be young, female, attractive, and cool (as indicated by dress and hair style). Therefore, agents that are young, female, attractive, and "cool" may be especially effective in influencing young women's attitudes and beliefs. That is, the agent's perceived similarity to its audience should affect the extent to which it is effective as an agent of persuasion.

However, people are also persuaded by those whom they perceive as experts (e.g., Chaiken & Maheswaran, 1994; Debono & Harnish, 1988; Hovland & Weiss, 1951). Thus, agents who are older and resemble the prototypical engineer (i.e., male and uncool) may also be influential. There is evidence that people are more likely to be affected by a similar other when an attitudinal, value-related issue is the object of influence (e.g., interest in engineering). Conversely, when the issue involves potentially verifiable facts (e.g., the utility of engineering), an expert is more influential (Goethals & Nelson, 1973). Likewise, Suls, Martin, and Wheeler (2000) proposed a triadic model of opinion comparisons. They found that people who are similar in related attributes provide the most meaningful information for evaluating preference, whereas people who have more expertise are preferred for belief (i.e., a potentially verifiable assertion about the true nature of the entity) evaluation. Thus, it is possible that an agent that resembles a prototypical engineer would be influential in changing tangible beliefs about what engineering involves (e.g., perceived utility of engineering). However, an agent that resembles its audience would be expected to influence value-based attitudes about engineering and beliefs about the audience's competence for engineering (i.e., self-efficacy). Therefore, different agent models may be effective in changing different types of beliefs and attitudes.

To examine these issues, in the current work we were interested in determining how agent appearance promotes change in attitudes and beliefs. In particular, we hypothesized that a peer-like interface agent (i.e., one that resembled the participants) would be the most persuasive and have the most positive impact on stereotypes, interest in engineering, and self-efficacy. In contrast, we predicted that an expert-like interface agent (i.e., one that looks like a prototypical engineer) would be the most persuasive and have the most positive impact on verifiable beliefs about the usefulness of engineering.

1.5. The current work

The purpose of Experiment 1 was to investigate the effect of a visually present interface agent, compared to a voice-only presentation, on young women's beliefs about engineering-related fields. In addition, of interest was whether or not a female agent persuader, that was similar to the participants, would be more effective than a male persuader. Building on the results of Experiment 1, the purpose of Experiment 2 was to investigate the specific effects of agent appearance (i.e., gender, age, coolness) on young women's attitudes and beliefs about engineering-related fields and their own abilities. In particular, we examined the effects of agents' appearance-related characteristics (gender, age, and coolness) on interest, engagement, and utility beliefs, as well as on stereotypes and self-efficacy.

2. Experiment 1

The educational literature suggests that agent voice alone may be sufficient to lead to positive learning outcomes (Mayer, Dow, & Mayer, 2003; Moreno, 2006; Moreno & Mayer, 2007; Moreno et al., 2001) and that the visual presence of an interface, or pedagogical, agent is unnecessary. However, other work would suggest that an agent, in combination with narrated instructions, should produce better learning than voice-only (e.g., Atkinson, 2002). In Experiment 1, we sought to examine whether a visually present agent was more effective than voice-only when the goal is to promote attitude change and self-efficacy in young women's beliefs about engineering-related fields. We hypothesized that the visual presence of an interface agent would result in more positive attitudes toward engineering and greater self-efficacy than the presence of a human voice without a visible agent given that the agent's anthropomorphic features, highlighted through its appearance, would be key persuasive mechanisms. Consistent with the psychological literature on social models, we hypothesized that a female persuader, who was similar to the young female participants, would be more effective than a male persuader for influencing interest and self-efficacy. However, the female agent should not be more effective than the male for influencing utility beliefs.

2.1. Method

2.1.1. Participants

Participants included 89 female undergraduate students enrolled in an introductory technology course who consented to participate (age $M = 19.7$ years, SD = 2.98). Of the participants, 68 were Caucasian, 5 were African–American, 3 were Asian/Asian American, 1 was Native American, 6 were Hispanic/Latino, 3 were biracial, and 3 were multiracial.

2.1.2. Design and materials

The study employed a 2 (gender: male vs. female) $\times$ 2 (agent visibility: not visible/voice-only vs. visible) between subjects factorial design. Participants were exposed to one of the four conditions.

Because we wanted to examine the effects of agent gender in Experiment 1, the agents used varied only in gender, and not in coolness nor attractiveness. The agents were both designed to be young ($\sim$25 years), "cool" (operationalized by clothing and hairstyle), and attractive (operationalized by facial features) and varied by gender. The agents were empirically validated to confirm that the target population perceived them to be young, cool, and attractive (Baylor & Plant, 2005). The agents (see Fig. 1) were created in Poser©. One male and one female human voice were recorded using the same script and similar inflection and tone. These sound files were used for both the visible agent conditions and the voice-only conditions, all within the same computer-based environment.

For the agent conditions, the audio files were synchronized with the agents using Mimic2Pro© to create lip-synching and emotional expressions. Several deictic gestures (e.g., pointing, head nodding) were also included. These gestures were identical for all agents. A fully integrated environment was created using Flash MX Professional©.

The assigned agent (set in a coffee shop location) introduced itself and provided a twenty-minute narrative about four female engineers, followed by five benefits of engineering careers. Periodically, the participants interacted with the agent to continue the presentation (i.e., clicked on the next topic to be addressed by the agent). In the voice-only condition the agent was not visible, but the interaction and the environment were the same.

2.1.3. Dependent variables

Because mathematics and the hard sciences (e.g., chemistry, physics) are familiar academic subjects to female undergraduates and are strongly related to the field of engineering, we assessed participants' attitudes and beliefs regarding these engineering-related fields. The dependent variables included utility, self-efficacy, and interest in engineering-related fields.

The dependent variables were all measured using a 7-point, Likert-type scale. Items for these scales were duplicated, so that half of the items in each scale referred to math and half referred to the hard sciences. Eight items (i.e., four for math and four for science) assessed participants' beliefs about the utility of engineering ($\alpha = .84$; e.g., "I would have many career opportunities if I was in the hard sciences"). Ten items assessed participants' self-efficacy in engineering-related fields ($\alpha = .89$; e.g., "I am confident that I could do well in math classes"). Finally, eight items assessed the participants'

Fig. 1. Male and female visible agents.

interest in taking engineering-related classes ($\alpha = .88$; e.g., "I will take a hard sciences course as an elective").

2.1.4. Procedure

The experiment was conducted in a regularly-scheduled classroom lab session where students accessed the online module through a web-browser (see Fig. 2 for screen-shot). The students were randomly assigned to one of the four conditions (voice-only male, voice-only female, female agent, male agent). Following completion, participants answered the online post-survey questions.

2.2. Results

To determine the effects of agent appearance, a series of 2 (female vs. male) $\times$ 2 (voice-only vs. agent) between-groups ANOVAs were performed on each of the key dependent variables (see Table 1).

2.2.1. Impact on beliefs about the utility for engineering

The analysis for utility revealed a significant main effect for agent visibility, $F(1,89) = 15.77$, $p < .001$. Participants who interacted with the visible agents were significantly more likely to believe that there is high utility for engineering than those who interacted with voice-only, $d = .89$, a large effect. There was not a significant main effect or interaction involving gender.

2.2.2. Impact on self-efficacy

The analysis of self-efficacy in engineering-related fields also revealed a significant main effect for agent visibility, $F(1,89) = 11.81$, $p < .001$. Participants who interacted with the visible agents were significantly more likely to report high self-efficacy in engineering-related fields than those who interacted with voice-only, $d = .72$, a large-moderate effect. There was not a significant main effect or interaction involving gender.

2.2.3. Impact on interest in engineering-related fields

The analysis of interest in engineering-related fields revealed again a significant main effect for agent visibility, $F(1,89) = 5.32$, $p < .05$. Participants who interacted with the visible agents were significantly more likely to report high interest in engineering-related fields than those who interacted with voice-only, $d = .52$, a moderate effect. There was not a significant main effect or interaction involving gender.

Fig. 2. Sample screenshot with visible agent.

Table 1
Scores for each dependant variable

Measure	Visible agent ($N = 42$)		Voice-only ($N = 47$)	
	M	SD	*M*	SD
Utility*	4.79	1.06	3.69	1.37
Self-efficacy*	3.97	1.16	3.07	1.35
Interest*	3.10	1.36	2.39	1.35

* $p < .05$.

2.3. Discussion

The first experiment examined the effect of animated anthropomorphic agents compared to a voice-only presentation on young women's beliefs about engineering-related fields. In particular, we were interested in young women's attitudes about whether engineering is useful and engaging, their interest in taking engineering-related classes, and their self-efficacy for engineering-related fields. Drawing from the literature on social models suggesting that a social model's appearance has important implications for attitudes and self-efficacy (e.g., Bandura, 1997; Goethals & Nelson, 1973) and on evidence from the learning domain suggesting that an agent in combination with narrated instructions produces better learning than voice-only (e.g., Atkinson, 2002), we hypothesized that the visual presence of an interface agent would result in more positive attitudes toward engineering and greater self-efficacy than a human voice without a visible agent. Even though there is also evidence for the lack of superiority of a visible agent compared to voice-only on a learning task with a high cognitive demand (Mayer, Dow et al., 2003; Moreno et al., 2001), there is reason to believe the agent presence would be more important for attitude change. For example, Moreno et al. (2001), (p. 34) themselves noted in their paper that "if the subject of the computer lesson was social rather than scientific, learning with the image of an agent might play a fundamental role." In addition, we anticipated that the female persuader (particularly when present in agent form) would be more influential than the male persuader.

In accordance with our first hypothesis, we found that participants who interacted with the visible agents were significantly more likely to believe that there is high utility for engineering, were significantly more likely to report high self-efficacy in engineering-related fields, were significantly more likely to report high interest in engineering-related fields, and were more likely to report high engagement in engineering-related fields (only marginal effect) than those who interacted with a human voice with no visible agent. The results provide support for the importance of the visual presence of an animated agent in attempting to change young women's attitudes toward engineering-related fields (Moreno et al., 2001). These findings suggest that the visual presence of a computer-based social model is significantly more persuasive than just hearing a voice alone.

Contrary to our hypothesis regarding the gender of the agent, we did not find that the female-delivered messages (with or without a visible agent) were more effective than those from a male. However, we suspect that gender may play a larger role in changing the young women's beliefs about engineering stereotypes than their interest, engagement, and self-efficacy. We further investigated this issue in Experiment 2.

3. Experiment 2

In Experiment 1, we found that a visible agent was more effective than voice-only in influencing young women's attitudes toward engineering-related fields. In Experiment 2, we were interested in determining the effect of the agent's social characteristics on participants' attitudes and beliefs about engineering. In particular, we examined the effects of agents' appearance-related characteristics (gender, age, and coolness) on interest, engagement, and utility beliefs, as well as on stereotypes and self-efficacy.

According to research in social psychology, appearance-related characteristics (e.g., age, gender, attractiveness, and coolness) are important in determining the persuasiveness of a social model (Bandura, 1997; Chaiken, 1979; McIntyer et al., 2003). In general, by providing information on whether or not a task is behaviorally appropriate, peer-models (i.e., social models that are similar to the observer or similar to how the observer would like to be) are the most effective in influencing attitudes (Bandura, 1986; Mussweiler, 2003; Schunk, 1987; Wood & Bandura, 1989). Thus, a peer-like social model agent (i.e., one that resembled the participants) would be the most persuasive and may have the most positive impact on beliefs, and self-efficacy. In addition, we were interested in following up Experiment 1 by examining the effects of agent characteristics on participants' stereotypes. Because stereotypes are attitudinal, we expected the peer-models to be the most influential in this area as well.

Nevertheless, when the issue involves potentially verifiable facts (e.g., the utility of engineering), people are persuaded by those whom they perceive as experts (Chaiken & Maheswaran, 1994; Debono & Harnish, 1988; Hovland & Weiss, 1951; Suls et al., 2000). Thus, agent models who are older and resemble the typical or stereotypic engineer (i.e., male and uncool) may also be more effective in influencing verifiable beliefs. Therefore, different agent models may be effective in changing different types of beliefs. For the purpose of application, we were interested in determining whether people's responses to agents are subject to the same rules as human social learning. We therefore varied the agents along more dimensions than in Experiment 1, which allowed us to test the effects of agents who, to varying degrees, resembled either a peer or a prototypical engineer.

We hypothesized that a peer-like agent social model (i.e., one that resembled the participants, specifically a female, young, cool agent) would be the most persuasive and have the most positive impact on stereotypes, attitudes, and self-efficacy of the young women. In contrast, the expert-like interface agent (i.e., one that looks like a stereotypical engineer, male, older, uncool) was predicted to be the most effective in influencing beliefs about the utility of engineering.

3.1. Method

3.1.1. Participants

Participants included 111 female undergraduate students enrolled in an introductory educational technology course at a Southeastern public university. Participants completed the study as part of their regularly scheduled class activities and received partial course credit for their participation, each electing through informed consent whether or not her data would be used for research purposes. Mean age of participants was 19.72 (SD = 1.96). Of the participants, 90 were White, 4 were African–American, 13 were Hispanic, 3 were multiracial, and 1 was Native American.

3.1.2. Research design and independent variables

Participants were randomly assigned to interact with one of eight agents. These agents were developed to differ on three factors: gender (male, female), age (older ~45 years, younger ~25 years) and coolness (cool, uncool) (see Fig. 3). "Coolness" was defined by hairstyle and clothes, with the "cool" agent having "cool" hairstyle and outfit. A pilot study was conducted to validate the agents' representation of the three appearance-related factors. Participants included 17 undergraduate psychology students (82% female) who completed the study as part of a regularly-scheduled laboratory class. Participants viewed still images of agents and evaluated the agents on their age, gender, and "coolness". The results of the pilot study indicated that participants perceived the interface agents as intended. That is, they had no trouble identifying the gender, relative age, or coolness of the agents. As anticipated, participants' ratings of the agents indicated that they consistently distinguished between older and younger agents, or cool and uncool agents.

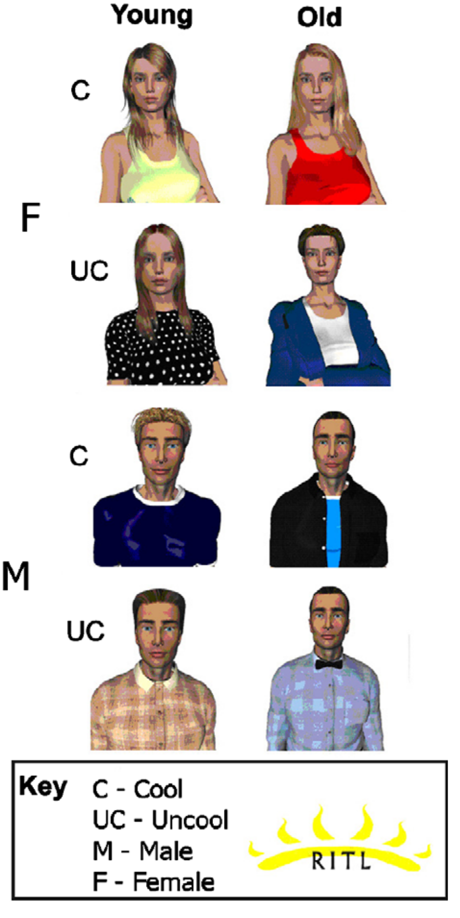

Fig. 3. Validated agents, differing by age, gender, and "coolness".

3.1.3. Dependent variables

Utility (e.g., "I would have many career opportunities if I was in the hard sciences"), self-efficacy (e.g., "I am confident that I could do well in math classes"), and engineering stereotyping (e.g., "People who take hard science classes are nerdy") were all measured using a 7-point, Likert-type scale. Scale reliabilities for the sample used in Experiment 2 were all acceptable (utility, $\alpha = .84$; self-efficacy, $\alpha = .89$; stereotypes, $\alpha = .80$; interest, $\alpha = .83$). The questionnaire was presented only once in Experiment 2, after participants had interacted with an agent model.

3.1.4. Research environment

Exactly as in the visible agent conditions in Experiment 1, the assigned agent (set in a coffee shop location) introduced itself and provided a twenty-minute narrative about four female engineers, followed by five benefits of engineering careers. This script was validated as effective in Baylor and Plant (2005). Periodically, the participants interacted with the agent to continue the presentation (i.e., clicked on the next topic to be addressed by the agent). In the voice-only condition the agent was not visible, but the interaction and the environment were the same.

3.1.5. Procedure

Students accessed the online application during a classroom computer laboratory session, each wearing headphones. Participants first interacted with the assigned agent, which delivered the persuasive message about engineering. Next, participants responded to questionnaire items within the online application.

3.2. Results

A series of 2: Agent gender (male vs. female) × 2: Agent age (younger vs. older) × 2: Coolness (cool vs. uncool) univariate analyses of variance were conducted on the indices for self-efficacy, interest, stereotype, and utility. The analysis for self-efficacy revealed an interaction between age and coolness, $F(1,103) = 4.43$, $p < .05$, such that participants who viewed an agent that was both young and cool had greater self-efficacy than participants who viewed agents that were young and uncool, older and cool, or older and uncool (see Fig. 4). Indeed, a post hoc t-test revealed participants who interacted with an agent that was both young and cool ($M = 3.98$) had more self-efficacy in engineering-related fields than participants who interacted with all agents that were not young and cool ($M = 3.29$, SD = 1.31), $t(109) = -2.80$, $p < .01$, $d = .58$.

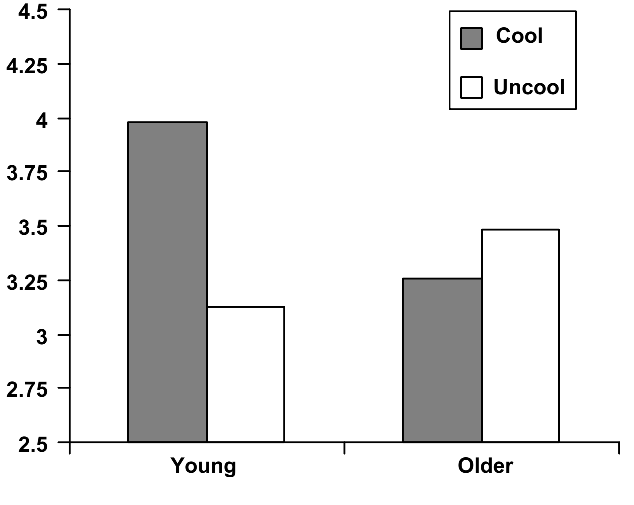

Fig. 4. The effect of agent coolness and age on self-efficacy.

The analysis for interest indicated only a nonsignificant trend for an interaction between agent age and coolness, $F(1,103) = 2.71$, $p = .10$. To clarify the nature of this finding, a *t*-test was conducted comparing all agents who were both young and cool to all other agents (i.e., older and cool, younger and uncool, older and uncool). Similarly to self-efficacy, participants who interacted with an agent that was both young and cool ($M = 3.05$, SD = 1.64) had more interest in engineering-related fields than participants who interacted with agents that were not young and cool ($M = 2.20$, SD = 1.33), $t(109) = -3.00$, $p < .01$, $d = .57$ (see Fig. 5).

The ANOVA for stereotype revealed a main effect for agents' gender $F(1,103) = 5.30$, $p < .05$. Participants who interacted with a female agent were significantly less likely to endorse the traditional engineering stereotype ($M = 3.29$, SD = 0.95) than participants who interacted with a male agent ($M = 3.68$, SD = 1.18), $d = .36$.

For utility, there was only a nonsignificant trend for gender, $F(1,103) = 3.18$, $p = .08$, such that male agents ($M = 4.62$, SD = .97) led participants to be slightly more likely to believe in the usefulness of engineering-related fields than female agents ($M = 4.19$, SD = 1.29).

3.3. Discussion

In general, the results supported our hypotheses. Agents that were similar to participants were most effective for enhancing self-efficacy and interest and for decreasing the traditional stereotype about engineers. For self-efficacy and interest, participants were affected by the agents' age and coolness. Young cool agents, whether male or female, were more effective for increasing participants' self-efficacy and interest than other agents. However, for stereotypes, it was the agents' gender that was most influential. To decrease the traditional engineering stereotypes, it was sufficient for a female agent to be presented as an engineer, regardless of her age or coolness. This was likely due to the fact that the stereotype of engineers is closely tied to the perception of them being male. Thus, the female agent presenting herself as an engineer was enough to challenge the young women's stereotypes of engineers.

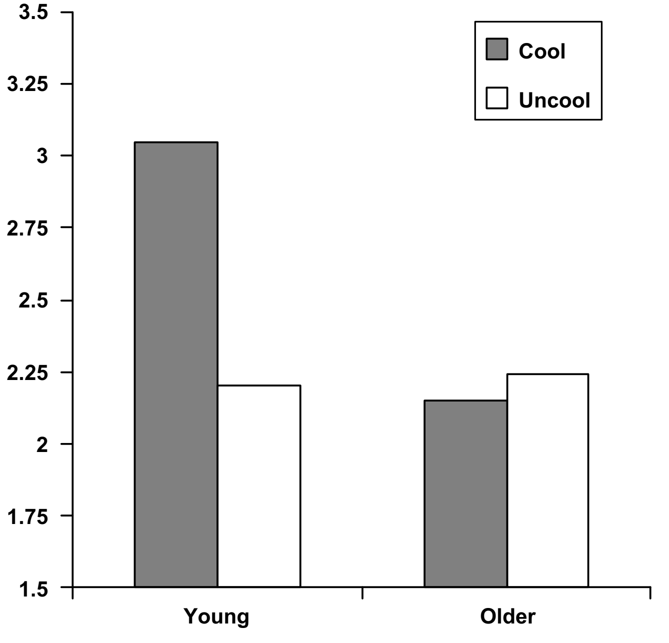

Fig. 5. The effect of agent coolness and age on interest.

Only a nonsignificant tendency for agents' gender was found to influence utility. We expected the agent that resembled a prototypical engineer to be most effective for enhancing utility beliefs. However, participants who saw a male agent were only marginally more likely to express a belief in the utility of engineering-related fields than those who saw a female agent. This marginal result was unqualified by agents' age or coolness.

4. General discussion

If women are to be adequately represented in the field of engineering, it will be necessary to address the negative beliefs and attitudes that prevent female students from pursuing and persevering in engineering careers. Prior research has indicated that interface agents can serve as effective persuaders to enhance student interest and motivation (e.g., Baylor, 2002; Baylor & Kim, 2005; Kim & Baylor, 2006). The results of these two experiments demonstrate that interface agents are also viable as social models to persuade female students to adopt more productive attitudes about potential careers and more confidence in their ability to succeed in them. In addition, in accordance with social agency theory, we have successfully demonstrated that people's interactions with agents follow human social-learning rules.

First, Experiment 1 demonstrated the importance of agent visibility for persuasion. Participants who interacted with the visible agents were significantly more likely to believe that there is high utility for engineering, report high self-efficacy and interest in engineering-related fields, and report high engagement in engineering-related fields (only marginal effect) than those who interacted with a human voice with no visible agent. Whereas voice alone may be sufficient for learning-related outcomes (Moreno et al., 2001), a visible agent together with the voice may be significantly more effective for attitude change. The current work adds to the growing empirical evidence showing that interface agents can positively impact attitudes and beliefs (Baylor & Kim, 2005; Baylor & Plant, 2005; Kim & Baylor, 2006). Consistent with the literature regarding low cognitive load, attitude change is most substantially affected when an agent is visibly present. In future research we plan to further investigate the importance of an agent voice vs. the importance of its visibility by directly comparing a visible agent with a computer-generated voice to a human voice with no visual agent. In addition, we plan to examine the effects of the persuasive message in the long term by observing the retention rates of female engineering students.

Second, Experiment 2 demonstrated that the agents that participants perceived as peer-like were the most effective in improving attitudes and beliefs. Young, cool agents improved female students' self-efficacy and marginally improved their interest in engineering-related fields. Female agent models, regardless of age or coolness, mitigated participants' negative stereotypes about engineering-related fields. These findings are consistent with social–psychological literature indicating that peer-like social models are effective persuaders (e.g., Bandura, 1986; Mussweiler, 2003; Schunk, 1987; Wood & Bandura, 1989) and that they can be more effective than expert-like social models for affecting responses to value-related attitude objects (Goethals & Nelson, 1973; Schunk, 2003; Suls et al., 2000). These results add to existent empirical evidence showing that people's interactions with agents follow human social-learning rules (Nass & Moon, 2000; Nass et al., 1995).

Attitudes about whether or not a field is interesting and about the veracity of negative stereotypes are largely value-based judgments. Thus, in the current work, participants' interest and stereotypes were most influenced by agents that were similar to how they saw themselves. Peer-like social models are also especially helpful for influencing students' self-efficacy (Schunk, 2003). Students who observe a similar other successfully perform a behavior are likely to increase their conviction that they too can perform the behavior successfully. Female students in Experiment 2 derived the largest self-efficacy benefits from interacting with agent models that were young and cool. It is likely that the perceived similarity of these agents to the participants, in age and in coolness, led to the peer-like agents' effectiveness. It is interesting to note that the important attributes of similarity for affecting self-efficacy were age and coolness, whereas the important attribute of similarity for mitigating negative stereotypes about engineering was gender. Although we expected gender to be an important attribute in affecting self-efficacy, it is also possible that the gender is a less important factor when it comes to peer influence on feelings of self-efficacy.

Because experts are usually persuasive regarding attitude objects that could be objectively verified (Chaiken & Maheswaran, 1994; Debono & Harnish, 1988; Hovland & Weiss, 1951; Suls et al., 2000), it was possible that the older, male expert-like model would be most influential for persuading students that engineering was a useful field. However, there was only a marginal effect of agent gender and no effect of agents' coolness or age on participants' utility beliefs (Experiment 2). The findings from the current work indicate that to maximize persuasiveness, an interface agent that is intended for use as a social model should be designed to look like an attractive peer, not like a teacher or other perceived expert.

A possible limitation to this study is the lack of a pre-test control for the students' attitudes towards engineering. Pre-existing differences between the groups could be claimed to be an alternative explanation to the results. Nevertheless, a pre-test in this case would have exposed the participants to the content and purpose of the persuasive message, thereby negating the purpose of the study (e.g., through expectancy or demand effects). Alternatively, by randomly assigning participants to experimental conditions, we were able to examine differences between the experimental groups without cueing participants to the content of the persuasive message. In addition, it can be argued that during the twenty-minute narrative the participants developed an awareness for the purpose of this study. Nevertheless, we believe that since all the of conditions were equally exposed to the narrative, resulting differences we have found between the conditions cannot be attributed to the participant's sense of awareness.

4.1. Future directions

An important question for future research will be to what degree increasing the similarity of the agent models to students increases their persuasiveness. In the current work, the agents' similarity to participants with respect to gender, age, and coolness was enough to increase their effectiveness. However, it is possible that agent models that resemble individual students more closely; for example, sharing hair color, eye color, or skin tone; would be more effective still. Similarly, it will be important in the future to determine whether agents' racial similarity to students has implications for their persuasiveness. Most participants in the current experiments were White and all interface agents appeared to be White. There is evidence that interface agents of similar ethnicity enhance motivation, particularly for African–American students (Baylor & Kim, 2003). However, agent–student ethnic similarity can also negatively impact learning (Moreno & Flowerday, 2006). Therefore, it is unclear how agents' racial similarity to participants might influence their effectiveness as social models.

Also of interest will be whether interface agents can serve as effective social models to convey productive attitudes, behaviors, and strategies to students within their chosen fields of study. Participants in the current work were enrolled in an introductory education class and were predominantly non-engineering students. Nonetheless, their responses to interacting with agents were decreases in negative attitudes about the field and increases in both positive beliefs about engineering and their abilities to succeed in relevant academic subjects. It seems likely that engineering students would benefit even more than the current participants from interacting with the agents and message used in these experiments.

Of course, developing a complete 3D animated agent as a social model ultimately involves more than designing its appearance. Other important multimedia design elements, which were held constant in these studies, include animation (e.g., emotional expressiveness, deictic gestures), voice (e.g., computer-generated vs. human, tone, accent), and overall agent persona (e.g., its personality, affective state). Future studies should consider such design elements and how they may potentially interact with the agent model's appearance.

There is a compelling need to develop effective social models for female engineering students and also for students of other fields in which women or other groups are currently underrepresented. Social models can enhance positive attitudes, mitigate negative ones, increase self-efficacy, and teach strategies for coping with difficult or challenging problems (e.g., Bandura & Schunk, 1981; Schunk, 1987, 2003; Schunk et al., 1987). Appropriate social models may not be available to many female students in fields that include relatively few women. Peer-models, or similar others, can be especially helpful to students, but may be sparse in some fields. Moreover, students cannot always be counted on to model successful behavior to their peers and those students who are successful may not be perceived as similar enough to warrant selection as a social model.

We have demonstrated that anthropomorphic interface agents can serve as persuasive social models for students. We have also determined that when the agent model appears similar to the target students, it increases its likelihood of serving as a credible persuader. Thus, we have also demonstrated that people's interactions with agents follow human social learning rules. These findings present a promising outlook for serving the needs of students who are underrepresented in their fields and, thereby, contributing to the growth and inclusiveness of fields such as engineering.

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