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Investigating the impact of pedagogical agent gender matching and learner choice on learning outcomes and perceptions

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ABSTRACT

The similarity attraction hypothesis posits that humans are drawn toward others who behave and appear similar to themselves. Two experiments examined this hypothesis with middle-school students learning electrical circuit analysis in a computer-based environment with an Animated Pedagogical Agent (APA). Experiment 1 was designed to determine whether matching the gender of the APA to the student has a positive impact on learning outcomes or student perceptions. One hundred ninety-seven middle-school students learned with the computer-based environment using an APA that matched their gender or one which was opposite in gender. Female students reported higher program ratings when the APA matched their gender. Male students, on the other hand, reported higher program ratings than females when the APA did not match their gender. Experiment 2 systematically tested the impact of providing learners the choice among four APAs on learning outcomes and student perceptions. Three hundred thirty-four middle-school students received either a pre-assigned random APA or were free to choose from four APA options: young male agent, older male agent, young female agent, or older female agent. Learners had higher far transfer scores when provided a choice of animated agent, but student perceptions were not impacted by having the ability to make this choice. We suggest that offering students learner control positively impacts student motivation and learning by increasing student perceptions of autonomy, responsibility for the success of the instructional materials, and global satisfaction with the design of materials.

1. Introduction

Multimedia learning environments are well-known to promote student learning (Mayer, 2005; Mayer, 2008). In such environments, verbal descriptions are presented either through narration or written text and are combined with visual depictions such as diagrams, tables, graphs, animations, or videos. A well-established line of research demonstrates that students learn better from words and graphics than from words alone (Mayer, 1989; Mayer, 2008; Moreno & Mayer, 1999). Such multimedia environments sometimes employ animated pedagogical agents to facilitate learning from multiple representations (e.g., text, diagrams, and equations) of information (Atkinson, 2002; Craig, Gholson, & Driscoll, 2002; Moreno, Mayer, Spires, & Lester, 2001; Moreno, Reisslein, & Ozogul, 2010; Ozogul, Reisslein, & Johnson, 2011).

Animated pedagogical agents (APAs) are humanlike or cartoon animated characters which are displayed within a computer-based learning environment to provide learners with pedagogical assistance (Bradshaw, 1997; Choi & Clark, 2006; Woo, 2009). APAs have the potential to increase learner engagement and the instructional methods they employ can increase learning (Baylor, 2009; Choi & Clark, 2006; Moreno, 2005). Moreno (2005) proposed that APAs have both internal and external properties which influence student learning. The internal properties of APAs concern the instructional methods used by the agent in facilitating learning. Instructional methods applied through APAs include directing learner attention through gestures (Moreno, 2004; Moreno et al., 2010) and delivering feedback messages, verbal guidance, and modeling (Azevedo et al., 2009; Graesser et al., 2004; Moreno et al., 2001). External properties of APAs relate to the image and voice of the agent, and include such agent characteristics as gender, age, ethnicity, and tone of voice. In the current investigation,

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the multimedia environment is the setting in which the animated pedagogical agent is used to facilitate instruction via narrated instruction and through signaling of relevant visual information using hand gestures. These internal characteristics are invariant across the versions of multimedia instruction. The reported experiments were conducted to examine the potential effects of external properties of the animated agent (i.e., age and gender) on learning and learner perceptions.

Although it may seem that external characteristics, such as agent gender or age, would have trivial consequences for learning or affect, some research suggests that these properties can play important roles (Ozogul et al., 2011; van Vugt, Bailenson, Hoorn, & Konijn, 2010). According to the similarity attraction hypothesis, humans are more attracted to others who appear and behave similarly to themselves (Byrne & Nelson, 1965). It has been suggested that this similarity attraction hypothesis may be applicable in computer-based learning environments, since computer users attribute social presence to computers (Moreno & Flowerday, 2006; Reeves & Nass, 1996). The following sections describe the use of APAs in multimedia environments and present relevant empirical background on APAs in multimedia.

1.1. APAs in multimedia

APAs are used in computer-based learning environments to provide learners with pedagogical assistance using one or more instructional methods, such as directing attention to relevant information, providing feedback messages, or delivering direct instruction (Dehn & van Mulken, 2000; Heidig & Clarebot, 2011; Moreno, 2005). Such instructional methods are intended to keep students focused on essential information and to provide context-specific learning strategies (Clark & Choi, 2005). Apart from the didactic objectives of APAs, they are also assumed to play motivational roles. By establishing a social interaction between learner and agent, APAs may maintain learners' engagement in a learning task, ultimately promoting learning outcomes (Baylor, 2011; Kim & Baylor, 2006; Moreno et al., 2001; Ryu & Baylor, 2005). According to the persona hypothesis, the visual presence of an APA in computer-based learning environments can increase learning outcomes and positively affect learners' perceptions of the learning experience (Cassell, Sullivan, Prevost, & Churchill, 2000; Lester et al., 1997; Mitrovic & Suraweera, 2000). The following section describes results from empirical work aimed at testing the persona hypothesis.

1.1.1. Persona hypothesis

Lester et al. (1997) presented learners with five different versions of a microworld centered on botany, each with a visually represented pedagogical agent "Herman the Bug". The different versions of the environment varied in the communicative behaviors used by the pedagogical agent. The authors found that all conditions led to higher scores at posttest, compared to pretest, and concluded that their findings supported a persona effect; that is, the visual presence of the animated agent led to increased student motivation and learning outcomes. This study has been criticized for not including a control group without the visual presence of the agent (Dehn & van Mulken, 2000; Heidig & Clarebot, 2011). In fact, few experimental studies have compared an APA condition to one using identical instruction without the visual presence of an agent. Heidig and Clarebot (2011) conducted a review of literature on APAs and found 15 experimental investigations which included an appropriate control condition. Nine of the 15 studies found no significant difference in learning between an APA condition and control. However, Atkinson (2002, experiment 2) found better learning outcomes from an APA condition, compared to text only or voice only conditions. Also, Moreno et al. (2010) found that an APA providing visual signaling within multiple representations led to better posttest scores and program ratings than arrow signaling or a control condition without such signaling.

In summary, results are not conclusive and debate continues concerning the assumption that the visual presence of an agent increases motivation or facilitates learning. Heidig and Clarebot (2011) suggest that a more appropriate research goal would be to determine under what conditions an APA can be helpful. The following section reviews research exploring the effect of agent gender on learners' perceptions or learning outcomes.

1.1.2. Agent gender studies

Arroyo, Woolf, Royer, and Tai (2009) explored the effect of different gendered learning companions on students' attitudes about math, students' emotions during learning, and learning outcomes. The authors showed that female high school and undergraduate students had better learning outcomes and more positive attitudes about math after learning with the male learning companion, compared to the female learning companion. Learners' open-ended responses did not suggest that the female students liked the male agent better. The authors suggest that gender stereotypes about mathematics transfer to the computer environment and the female students thus regard the male companion's information as more credible. Similar findings were obtained with undergraduate students learning about blood pressure (Moreno, Klettke, Nibbaragandla, & Graesser, 2002); learning outcomes were higher with male agents than female agents, and stereotyping scales provided some evidence that participants applied gender stereotypes to the animated agents.

Baylor and Kim (2003) investigated the effect of student gender, student ethnicity, agent gender, and agent ethnicity on learning and learner perceptions of pre-service teachers learning about instructional design. Their results indicated that, overall, learners rated male agents as more extroverted. Although learners reported greater satisfaction in their performance and more use of self-regulation after learning with a male agent, learning did not differ between male and female agent conditions. Kim, Baylor, and Shen (2007) had mixed results from two experiments with undergraduate students learning about instructional design. The first experiment used computer literacy students and demonstrated better recall from a male agent than a female agent; the second experiment did not replicate this finding with pre-service teachers.

Plant, Baylor, Doerr, and Rosenberg-Kima (2009) found that a female agent led to better math posttest scores, higher ratings of engineering utility, interest and self-efficacy than a control (no agent) condition, whereas the male agent only led to increased self-efficacy compared to the control condition. Furthermore, math scores were higher in the female agent condition compared to the male agent condition. The authors suggest that these middle-school students have many experiences with female teachers, and thus view them as credible sources of information. Their interpretation may explain why this study stands out from other work demonstrating better outcomes with male agents.

To summarize, the results from several previous studies have shown that male agents often lead to better learning outcomes (Arroyo et al., 2009; Kim et al., 2007; exp. 1; Moreno et al., 2002) and more positive evaluations of the learning experience (Arroyo et al., 2009; Baylor & Kim, 2003; Moreno et al., 2002) in math and technical domains than female agents; conversely, Plant et al. (2009) found better