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Animated agents and learning: Does the type of verbal feedback they provide matter?

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ABSTRACT

The current study was conducted to investigate the effects of an animated agent's presence and different types of feedback on learning, motivation and cognitive load in a multimedia-learning environment designed to teach science content. Participants were 135 college students randomly assigned to one of four experimental conditions formed by a 2 × 2 factorial design with agent presence as one factor (agent vs. no-agent) and type of verbal feedback it provided as the other factor (simple feedback vs. elaborate feedback). Results revealed that participants who learned with the animated agent that delivered elaborate feedback had significantly higher scores on a learning measure compared to participants who learned with an agent that provided simple feedback. The results are interpreted from both social agency and cognitive load theoretical perspectives.

1. Introduction

As researchers continue to investigate methods and guidelines to increase the effectiveness of learning environments, attention is being focused on how motivation, social interaction and cognitive processes impact learning in multimedia environments (Mayer, Sobko, & Mautone, 2003; Moreno, 2007; Moreno & Mayer, 2007). Multimedia environments provide an interface that incorporates words and pictures in ways that can potentially capitalize on these factors and enhance learning (Mayer, 2005). For example, researchers have explored using animated pedagogical agents to enhance social interaction between the computer and the learner and promote learning processes (Atkinson, 2002; Craig, Gholson, & Driscoll, 2002; Dunsworth & Atkinson, 2007). An animated pedagogical agent is a lifelike character that provides instructional information through verbal and nonverbal forms of communication. An agent incorporates some or all of the following features: (a) a human-like look, (b) locomotion, (c) goal-directed gestures, (d) facial expression, (e) gaze, (f) a human voice, (g) personalized speech, and (h) interactive behavior by reacting to a learner's actions (e.g., providing verbal feedback). This study investigated the impact of an animated agent and the type of corrective feedback on learning, motivation and cognition in a multimedia environment.

1.1. Social agency theory perspective

Social agency theory (Atkinson, Mayer, & Merrill, 2005; Mayer, Sobko, et al., 2003) is one of the theoretical frameworks that researchers use to investigate the effectiveness of animated pedagogical agents in multimedia learning environments. According to this theory, an animated agent that appears on a computer screen and provides learners with verbal and/or non-verbal learning cues has the potential to prime their social-interaction schema and involve the learner in social interaction. As a result, learners may be triggered to interact with

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the agent in a computer-based multimedia learning environment in much the same way they would interact with their peer, mentor or teacher in a classroom. Once learners perceive a computer-based instructional episode as a social event, they apply social rules—the conventions for human-to-human communication—when they are interacting with the computer (Reeves & Nass, 1996; Van der Meij, 2013). There are a number of social norms primed by the human–computer interaction—one of which is the *cooperation principle* (Grice, 1975). Grice proposed that a person who is listening to someone talk in a human-to-human communication scenario will assume that the speaker is making a concerted effort to clearly communicate by being informative, accurate, relevant, and concise. Therefore, the learner is potentially motivated in this situation to make sense of what is being presented to him/her and will be more likely to process the information deeply and achieve meaningful learning. In effect, they will be more motivated to select relevant information and integrate it with prior knowledge.

There is modest empirical evidence in the educational research literature supporting social agency theory as several studies have revealed positive learning effects of presenting an animated pedagogical agent in a multimedia environment. For instance, Atkinson (2002) conducted a study in which an animated parrot (Peedy) was used in a multimedia program to deliver worked-example instruction about proportion-word problems. He found that participants studying content with the agent that narrated the instruction performed significantly better on learning outcome measures than their counterparts studying the same content with narrated instruction but no agent. This finding indicated that the presence of the agent enhanced the learning effectiveness of the multimedia environment (i.e., image effect). Other studies (e.g., Dunsworth & Atkinson, 2007; Lester et al., 1997; Lusk & Atkinson, 2007; Moreno, Mayer, & Lester, 2000; Moreno, Mayer, Spires, & Lester, 2001; Yilmaz & Kılıç-Çakmak, 2012) also showed that the presence of an agent fostered learning in a multimedia environment. Kim and Ryu (2003) reviewed 28 studies and found a strong positive learning effect for visually presented agents that are utilized to deliver instruction. In addition, past research revealed the positive impact of agents' voices (e.g., personalized speech) and affective behaviors (e.g., facial expressions) on learners' affective states (e.g., motivation and interest) in multimedia environments (Atkinson et al., 2005; Baylor & Kim, 2005, 2009; Kim & Baylor, 2006; Kim, Baylor, & Shen, 2007). These findings provide further evidence of social-motivational aspects of agents. Additionally, Atkinson et al. (2005) found that learners who studied worked examples that were narrated by an agent with a human voice rated the agent's speech more positively and had better performance on transfer test questions than their peers who studied examples accompanied by the same agent with a computer voice. Therefore, learning, motivation and cognition should all be considered and investigated in multimedia environments, as these three factors are influenced by different instructional methods and media (Brünken, Plass, & Moreno, 2010; Moreno, 2010; Moreno & Mayer, 2007).

1.2. Cognitive load theory perspective

Cognitive load theory (CLT; Paas, Renkl, & Sweller, 2003; Schnotz & Kurschner, 2007; Sweller, 1994; Sweller, Ayres, & Kalyuga, 2011; Sweller, van Merrienboer, & Paas, 1998) provides another theoretical framework for researchers to explain their findings in agent-based learning environments. CLT is built around a multicomponent working memory model (Baddeley, 2007) that assumes humans process information via dual sensory channels—audio/verbal channel and visual/pictorial channel and consequently have a limited working memory capacity. During the learning process, learners must select relevant information from the two channels, organize it in working memory and integrate it with their prior knowledge. This process is essential for learning, as it facilitates schema construction and the transfer of information to long-term memory (Sweller, 2005). Learners experience cognitive load when their working memory capacity has been exceeded.

There are three sources of cognitive load—intrinsic load, extraneous load and germane load. Intrinsic load is due to the natural complexity of the learning content that results from the number of interacting elements (element interactivity) necessary to process the task (Sweller, 2005). More interactive elements increase the intrinsic load, the working memory load (Sweller, 2010) and the difficulty level of the task. Extraneous load is caused by ineffective instructional design and should be reduced to promote learning. Finally, germane load is caused by the necessary effortful processing that is required to facilitate schema acquisition. Regardless of the source, the underlying cause of cognitive load that taxes limited working memory resources is proposed to be element interactivity (Sweller, 2010). Sweller suggested that this notion may make it difficult to assess how much load is caused by the different sources but that overall cognitive load can be still be determined and there is "…no reason why the currently commonly used subjective ratings of task difficulty…cannot be used to determine changes in overall cognitive load" (p. 128).

The design of instruction, or the instructional format, has the potential to impact how learners interact with a learning environment and experience cognitive load. For example, it could be argued that a multimedia learning program designed with an animated agent has no effect or even negative effect on learning. According to Harp and Mayer (1998), an animated agent that displays gestures, gaze, facial expressions or locomotion may provide learners too many seductive details and cause learners to split their attention from relevant information and consequently experience extraneous load (or additional element interactivity) in the learning environment. Results revealed from several studies (Chen, 2012; Choi & Clark, 2006; Craig et al., 2002; Mayer, Dow, & Mayer, 2003) support this claim. For instance, in Choi and Clark's study (2006), either an animated agent or an arrow was used in a multimedia program to teach an English language topic about relative clauses. However, the study failed to reveal any learning benefits for those who learned from the animated pedagogical agent. This finding is consistent with Mayer's (Mayer, Dow, et al., 2003) results, who found that participants who studied with an animated agent did not significantly improve on the transfer test compared to their peers who learned without an agent.

Irrespective of theoretical orientation, the current education research literature on the effectiveness of animated agents is rich with diverse research hypotheses and varied empirical outcomes (for review, see Heidig & Clarebout, 2011). In fact, some researchers have concluded that no generalization can be made about whether it is advantageous to embed an agent in a learning environment. Instead, research should investigate the specific conditions under which an agent enhances learning by taking into account a series of potential moderators, such as learner characteristics, the agent's functions, the agent's design, learning environments, and the type of knowledge (Atkinson et al., 2009; Johnson, DiDonato, & Reisslein, 2013; Kim & Wei, 2011; Ozogul, Johnson, Atkinson, & Reisslein, 2013; for review, see Dehn & van Mulken, 2000; Heidig & Clarebout, 2011). Therefore, they recommended that empirical research should address the effect of a specific type of agent in a specific domain. In order to shed light on the mixed and inconclusive