Learning with Human and Virtual Instructors Who Display Happy or Bored Emotions in Video Lectures

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Abstract

In this study, we investigate whether the affective state (happy or bored) of a human or virtual instructor in an instructional video on statistics yields different learning processes and outcomes. The positivity principle states the emotional state of the instructor is recognized by students (hypothesis 1) and affects their emotional state (hypothesis 2), motivational state (hypothesis 3), and learning outcomes (hypothesis 4). The equivalence principle states that people respond to the emotional tone of computerized onscreen agents in the same way as for human instructors (hypothesis 5). In a 2x2 between subjects design, participants were assigned to watch a statistics video in one of four groups: Happy Human (HH), Happy Agent (HA), Bored Human (BH), and Bored Agent (BA). Then, they rated the emotional state of the instructor, rated their own emotional state, rated their motivational state, and took a posttest. The findings support predictions 1, 2, and 3 of the positivity principle but not prediction 4, perhaps because an immediate test was not sensitive enough. The equivalence principle (hypothesis 5) was partially supported as the human and agent groups showed similar rating patterns although the effects were stronger for human instructors for recognizing the instructor's emotion. As education transitions online, it is important to note that students are happier and more motivated when they learn from happy instructors than from bored instructors.

Keywords: emotion, affect, multimedia learning, instructional video, animated pedagogical agents

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Objective and Rationale

As instruction transitions to online venues, it becomes increasingly important to establish evidence-based principles for how to design video lectures (Fiorella & Mayer, 2018; Mayer, Fiorella, & Stull, 2020). Although most previous work has examined cognitive processes underlying instructional design of multimedia instruction, including video lectures (Mayer, 2014, 2020; Sweller, Ayres, & Kalyuga, 2011), research is emerging on affective processes in multimedia learning including the emotional design of instruction (Mayer & Estrella, 2014; Pekrun & Linnenbrink-Garcia, 2012; Pekrun & Perry, 2014; Plass, Heidig, Hayward, Homer, & Um, 2014; Um, Plass, Hayward, & Homer, 2012). The goal of the present study is to examine how the emotional tone (i.e., happy or bored) displayed by a human or virtual instructor in a video lecture on statistics affects learning processes and learning outcomes. Emotional tone is conveyed through the voice and gestures of the instructor. Specifically, we want to know whether students learn differently with a happy instructor than a bored instructor in a video lecture, even when the script and slides are identical, and whether the instructor's emotion plays the same role with human instructors and virtual instructors.

The Covid-19 pandemic has accelerated a move from face-to-face to remote instruction, which highlights the need to keep students motivated as they learn online (Ghazi-Saidi et al., 2020; Means & Neisler, 2020). In particular, during the pandemic, there is an increased need to consider the role of affect in keeping students motivated to learn in online environments (Kim & Frick, 2011; Shea et al., 2006), especially given the special challenges of maintaining motivation during online learning (Chen & Jang, 2010; Harnett, 2016; Tettegah, 2016).

Literature Review

One major development in our understanding of emotion occurred with Russell's core affect model, which defined different emotional states (Russell, 1980). Simply stated, Russell proposed that emotions can be categorized based on two dimensions: valence, which runs from positive (or pleasant) to negative (or unpleasant); and arousal, which runs from active to passive. These two dimensions yield four basic emotional states: the happy emotional state consists of active and positive affective states, the content emotional state consists of passive and positive affective states, the frustrated emotional state consists of active and negative affective states, and the bored emotional state consists of passive and negative affective states. This analysis provides the basis for the current study, in which we focus on the happy and bored conditions.

In addition, we draw on a modified version of the Cognitive-Affective Theory of Learning with Media (CATLM; Moreno & Mayer, 2007), which adds the role of affect to the Cognitive Theory of Multimedia Learning (CTML; Mayer, 2014, 2020). The cognitive-affective model of learning with instructional video shown in Figure 1 states that learning occurs in four key steps, as exemplified when the instructor displays positive emotion: (1) the learner recognizes the instructor's affective state, (2) the recognition of the instructors affective state causes the learner to feel the same emotion as the instructor, (3) the learner's newly acquired affective state triggers positive changes in motivational state, and (4) the learner's motivational state leads to a learning outcome that is better for positive instructors. In contrast, when the instructor displays negative emotion, the learner recognizes and adopts negative emotion, experiences lower motivation, and performs worse on a posttest.

In this study, we examine whether animated pedagogical agents in an online video lesson can convey emotional tone to learners as well as human instructors. Animated pedagogical agents are onscreen characters who are intended to support learning (Baylor & Kim, 2009; Johnson, Rickel, & Lester, 2000). An important aspect of research on onscreen agents concerns techniques for giving them social and emotional cues that promote better motivation and learning in learners, including personalized language (Moreno et al., 2001; Craig, Gholson, & Driscoll, 2002; Wang et al., 2008), human-like gesture and voice (Li, Wang, Mayer, & Liu, 2020; Mayer, 2020; Mayer & Dapra, 2012; Wang, Li, Mayer & Lui, 2018), and gender matching between the agent and the learner (Makransky, Borre-Gude, & Mayer, 2019). There is preliminary evidence that embodiment cues such as gesture and voice have potential for conveying emotional tone in video lectures (Lawson, et al., in press; Mayer, 2020). Importantly, there is corresponding evidence for video lectures involving human instructors as well as lectures based solely on voice (Fiorella & Mayer, 2016; Fiorella, Stull, Kuhlmann, & Mayer, in press; Lawson et al., in press; Mayer, 2020).

In this study, we focus on the emotional tone of human or virtual instructors in online video lectures as a vehicle for promoting effective learning. Research on emotional design is concerned with how create online instructional material that primes positive emotional responses in learners that lead to better learning processes and outcomes. Thus, the current study builds on our understanding of emotional design, which is the idea of optimizing instructional design with specific emotional features particularly concerning the facial expression of onscreen characters (Loderer et al., in press; Mayer, in press; Pawar, Tam, & Plass, in press; Plass & Kaplan, 2016). Previous research has shown that a positive emotional design leads to increased positivity towards the material being studied, greater motivation to study the material, and greater satisfaction with the lesson as a whole (Um et al., 2012). Furthermore, in a video about how a virus causes a cold, the presence of emotional facial expressions of artificial characters increased learning outcomes and effort ratings, compared to the control group (Mayer & Estrella, 2014). In addition, further studies have found that in a digital game, certain facial expressions of artificial game characters have the greatest effect on perception of affect by participants, compared to shape or color of the animated agent, and that perception of a positive affect has an effect on learning outcomes (Plass et al., in press; Plass et al., 2014). These findings support the idea of a including a positive instructor as a method for improving learning outcomes and helps define some of the key features of a positive instructor.

Theoretical Framework and Predictions

The positivity principle states that people learn better from positive instructors than from negative instructors. As reflected in the cognitive-affective model of learning with instructional video exemplified in Figure 1, instructors who display positive emotion cause the learner to recognize positive emotion, feel positive emotion, increase their motivation to learn, and improve their learning outcome; whereas instructors who display negative emotion create the opposite pattern.

Hypothesis 1: Based on the positivity principle, we predict that the learners in the happy conditions will rate the emotion of the instructor as more happy and less bored, compared to learners in the bored conditions.

Hypothesis 2: Assuming that the participants can recognize the emotion of their instructor and according to the positivity principle, we predict that learners in the happy conditions will rate themselves as more happy and less bored, compared to learners in the bored conditions.

Hypothesis 3: Next, the positivity principle allows us to predict that participants in the happy conditions will report being more motivated, compared to those in the bored conditions.

Hypothesis 4: Finally, the positivity principle predicts that the participants in the happy conditions will show greater learning outcomes compared to those in the bored conditions.

In addition, the media equation theory states that people accept a computer as a social partner just as easily as they accept a human (Reeves, & Nass, 1996). According to this theory, the instructor's emotional tone will have the same effect for a virtual instructor (i.e., an onscreen animated character) as for a human instructor (i.e., a video showing a human). We refer to this idea as the equivalence principle.

Hypothesis 5: According to the equivalence principle based on media equation theory, we predict that the happy agent conditions and the happy human conditions will be rate the instructor as equally happy (hypothesis 4a), will rate their own emotion as equally happy (hypothesis 4b), will rate their level of emotion as equally high (hypothesis 4c), and will perform equally on the posttest (hypothesis 4d).

The predictions concerning the positivity principle are summarized in the left side of Table 1a; the predictions concerning the equivalence are summarized in the left side of Table 1b.

Method

Participants and Design

The participants were 112 college students at a university in the United States who participated in the study for course credit. The mean age was 19.11 years (SD = 1.18), and there were 28 men and 84 women. The study was based on a 2x2 between subjects design, with the factors being type of instructor (human versus agent) and emotion of instructor (happy versus bored). This yielded four groups: 30 participants served in the happy human group (HH), 28 served in the bored human group (BH), 28 were in the happy agent group (HA), and 26 were in the bored agent group (BA).

Materials

The materials included a pre-questionnaire, posttest, post-questionnaire, and four computer-based video lessons.

Pre-questionnaire

The pre-questionnaire was an 8.5 x 11-in sheet of paper that asked participants to provide their age and gender, and included a 5-point rating scale in which participants self-rated their level of statistical knowledge from “Very low” (0) to “Very high” (4).

Posttest

The posttest was a PowerPoint presentation that consisted of 20 open-ended questions, including retention questions (e.g., “What does R stand for?”, “What is the formula for binomial probability?”), computational problems (“P = 1/2 , N = 8, R = 5, What is C(N,R)?”), word problems (e.g., “A coin is flipped six times, giving a sequence of heads and tails. How many different sequences contain two heads and four tails?”), questions (e.g., “Can P be greater than 1-P?”), and unsolvable problems for which the correct answer is “unsolvable” (e.g., “N = 2, R = 3, P = ½, What is C(N,R)?”). A sheet containing relevant formulas was provided for questions involving computations. Participants were given a blank sheet of paper to write their answers. Participants clicked on a NEXT button to go on to the next item and could not go back to previous items. Cronbach's alpha was 0.78.

Post-questionnaire

The post-questionnaire consisted of a sheet of paper with rating items. Four of the items involved rating the instructor's level of each of four emotions on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree):

The instructor was happy.

The instructor was content.

The instructor was frustrated.

The instructor was bored.

These items are intended to test hypotheses 1 and 5a, concerning the first link (i.e., learner recognizes the instructor's emotion) in the Cognitive Affective Model of Learning with Instructional Video in Figure 1.

Three of the items involved rating aspects of the learner's level of motivation on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree):

I was motivated to pay attention to the lesson material I watched.

I enjoyed learning about this information.

I would like more lessons like this one.

These items are intended to test hypotheses 3 and 5c, concerning the third link (i.e., learner reacts to the instructor's emotion) in the Cognitive Affective Model of Learning with Instructional Video in Figure 1.

Four of the items involved rating the learner's level of each of four emotions on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree).

The instructor made me feel happy.

The instructor made me feel content,

The instructor made me feel frustrated.

The instructor made me feel bored.

These items are intended to test hypotheses 2 and 5b, concerning the second link (i.e., learner adopts the instructor's emotion) in the Cognitive Affective Model of Learning with Instructional Video in Figure 1.

Videos

There were four instructional videos corresponding to the four treatment groups: happy human (HH), bored human (BH), happy agent (NA), and bored agent (BA). In each video, a young female instructor stood next to a series of slides as she lectured. The videos lasted approximately 10 minutes and involved the statistical topic of binomial probability. The lesson started with definitions of a “trial,” “outcome,” “success,” and “failure”, and then transitioned into more complex concepts, “Joint Probability of a Sequence” and “Combination Equation.” Finally the video finished by combining everything taught into the “Binomial Probability Equation.” The video included examples for each topic, and explained each equation as it came up. The videos all shared an identical script and slides, but the instructor was either human or an animated agent and the affective state of the instructor was either happy or bored as reflected by differences in the instructor’s tone of voice, gestures, body stance, facial expression, and eye gaze. The human conditions consisted of two videos created in a television studio with an actress from the Department of Theater and Drama, one video in which the actress used happy gestures, body stance, facial expression, eye gaze, and voice and one video in which she used bored gestures, body stance, facial expression, eye gaze, and voice. The agent conditions consisted of an animated version of each of the two human videos in which the human was replaced with an animated agent who resembled the human instructor, had the same voice as the human instructor, and mimicked her gestures, body stance, facial expression, and eye gaze. Screenshots of the human and agent instructors can be seen in Figure 2.

Apparatus

The equipment consisted of 3 iMac desktop computer systems with 21.5-in screens (Intel Core i3 - 3.6GHz, 8GB Memory, 1TB Hard Drive), and over-the-ear headphones.

Procedure

Participants were tested in groups of up to 3 per session, with each participant in a session randomly assigned to one of the four groups, and seated in a cubicle that provided visual isolation from other participants. To protect confidentially, each participant was assigned an ID number, keyed to the questionnaires and posttest. First, each participant was given a consent form to sign. Then, they were given the pre-questionnaire, to complete at their own rate. Next, the researcher instructed each participant to put their headphones on, and started the video for each of them on an iMac computer. There was no opportunity to pause, take a break, or take notes. After the lesson ended, the researcher passed out sheets of paper to the participants, started the post-test slideshow for each participant, and informed them that when writing their answers on these sheets they should not go back to any of the questions they had already answered, and should mark a question as "unsolvable" if they believed it was not possible to solve it. Once participants completed the posttest, the researcher collected their answer sheets, and passed out the post-questionnaire to be completed at the participants' own pace. Lastly, the researcher collected the post-questionnaire and thanked the participants for their participation. The researcher obtained IRB approval and followed guidelines for treatment of human subjects.

Results

Do the Groups Differ on Basic Characteristics?

In order to adequately interpret the results, it is important to determine whether the groups differ significantly on basic characteristics. Analysis of variance or chi square tests were conducted to compare the groups on self-rated statistical knowledge, age, and gender. As shown in the top line of Table 2a, no statistically significant difference was found in self-rated statistical knowledge between different types of instructors, $F(1,108) = 0.41$, $p = 0.52$, or different instructor emotions, $F(1,108) = 0.13$, $p = 0.73$, and there was no significant interaction, $F(1,108) = 0.01$, $p = 0.93$. As shown in the second line of Table 2a, no statistically significant difference was found in age between different types of instructors, $F(1,108) = 0.02$, $p = 0.90$, or different instructor emotions, F(1,108) = 0.58, p = 0.45, and there was no significant interaction, F(1,108) < 0.01, p = 0.98. The groups did not differ significantly on the proportion of men and women, $\chi^2(3) = 3.574$, p = 0.31 (HH: 19 females and 11 males; HA: 23 females and 5 males; BH: 24 females and 6 males; BH: 18 females and 8 males). We conclude that the groups did not differ on basic characteristics.

Are Learners Aware of the Emotional Stance of the Instructor?

The first step in the cognitive-affective model of learning with instructional video summarized in Figure 1 is that the learner recognizes the emotional stance of the instructor–particularly, the learner recognizes whether the instructor displays positive emotion (such as happy or content) or negative emotion (such as bored or frustrated). Mean ratings (and standard deviations) of the instructor on scales for happy, content, bored, and frustrated are shown in Table 2b for each of the four treatment groups, and Figure 4 shows the interactions in graphical form. For each emotion rating scale, we conducted a 2x2 analysis of variance, with type of instructor (human or agent) and type of emotion (happy or bored) as factors, and the rating (from 1 to 5) as the dependent measure.

The first row of Table 2b shows the mean ratings (and SDs) of the instructor's level of happy emotion for each of the four groups. Consistent with prediction 1 of the positivity principle, students who viewed the happy instructor gave a significantly higher rating on the happy scale ($M = 4.07$, $SD = .92$) than did students who viewed the bored instructor ($M = 1.59$, $SD = 1.07$), $F(1,110) = 180.58$, $p < 0.001$, $d = 2.48$. Consistent with prediction 5a based on the equivalence principle, there was no significant difference in the happy rating between human instructors and agents instructors, $F(1,110) = 1.82$, $p = 0.18$. However, this support is tempered by a significant interaction between type of instructor and emotion of instructor, $F(1,110) = 6.05$, $p = 0.02$, in which the effect of emotion was stronger with humans instructors than with agent instructors as displayed in the first frame of Figure 4.

The second row of Table 2b shows the mean ratings (and SDs) of the instructor's level of content emotion (which is considered a positive emotion) for each of the four groups. Consistent with prediction 1, students who viewed the happy instructor gave a significantly higher rating on the content scale ($M = 4.14$, $SD = .87$) than did students who viewed the bored instructor ($M = 1.64$, $SD = 1.07$), $F(1,110) = 193.10$, $p < 0.001$, $d = 2.56$. Consistent with prediction 5a based the equivalence principle, there was no significant difference in the content rating between human instructors and agent instructors, $F(1,110) = 0.29$, $p = 0.59$. However, this support is tempered by a significant interaction between type of instructor and emotion of instructor, $F(1,110) = 193.10$, $p = 0.001$, in which learners were better at recognizing the emotion of human instructors than agent instructors as displayed in the second frame of Figure 4.

The third row of Table 2b shows the mean ratings (and SDs) of the instructor's level of bored emotion for each of the four groups. Consistent with prediction 1, students who viewed the happy instructor gave a significantly lower rating on the bored scale ($M = 2.05$, $SD = 1.16$) than did students who viewed the bored instructor ($M = 4.50$, $SD = 1.04$), $F(1,110) = 144.36$, $p < 0.001$, $d = 2.22$. Consistent with prediction 5a based on the equivalence principle, there was no significant difference on the bored rating between human instructors and agent instructors, , $F(1,110) = .10$, $p = 0.77$. This support is qualified by a significant interaction between type of instructor and emotion of instructor was significant, $F(1,110) = 6.75$, $p = 0.01$, in which learners were better at recognizing the emotion of human instructors than agent instructors as displayed in the third frame of Figure 4.

The fourth row of Table 2b shows the mean ratings (and SDs) of the instructor's level of frustrated emotion (which is considered a negative emotion) for each of the four groups. Consistent with prediction 1, students who viewed the happy instructor gave a significantly lower rating on the frustrated scale ($M = 1.34$, $SD = 0.64$) than did students who viewed the bored instructor ($M = 3.54$, $SD = 1.29$), $F(1,110) = 140.18$, $p < 0.001$, $d = 2.16$. Consistent with prediction 5a based on the equivalence principle, there was no significant difference the content rating between human as instructors and agents as instructors, $F(1,110) = 2.34$, $p = 0.13$. However, this support is tempered by a significant interaction between type of instructor and emotion of instructor, $F(1,110) = 10.09$, $p = 0.01$, in which the effect of emotion was stronger with human instructors than with agent instructors as displayed in the fourth frame of Figure 4.

Overall, in four of four tests, these results support hypothesis 1, which states that learners are able to recognize whether the instructor is displaying a positive (i.e., happy or content) or negative (i.e., bored or frustrated) emotional tone while lecturing. Thus, there is strong and consistent evidence for the first step in the positivity principle, in which the learner recognizes the emotional state of the instructor. These results partially support hypothesis 5 based on media equation theory, in which there is no overall difference between ratings of the same emotion displayed by human and virtual instructors but an interaction indicating that the effects are stronger for human instructors. Thus, learners recognize the emotions being displayed by virtual instructors, but not as well as they can recognize the emotions of human instructors in this study.

Do the Learners Feel the Same Emotional State as the Instructor During Learning?

The second step in the cognitive-affective model of e-learning summarized in Figure 1 is that the learner feels the same emotional tone as the emotional tone displayed by the instructor (i.e., happy instructors cause learners to feel positive emotions such as happy or content, and bored instructors cause learners to feel negative emotions such as bored or frustrated). Table 2c shows the mean ratings (and standard deviations) of the learner's emotion during learning on scales for happy, content, bored, and frustrated for each of the four treatment groups. For each emotion rating scale, we conducted a 2x2 analysis of variance, with type of instructor (human or agent) and type of emotion (happy or bored) as factors, and the rating (from 1 to 5) as the dependent measure.

The first row of Table 2c shows the mean ratings (and standard deviations) of the learner's level of happy emotion for each of the four groups. Consistent with prediction 2, students who learned with a happy instructor gave a higher rating of their own level of happy emotion during learning (M = 3.33, SD = 1.02) than did students who learned with a bored instructor (M = 1.54, SD = 0.95), $F(1,110) = 93.18$, $p < 0.001$, $d = 1.82$. Consistent with prediction 5b, there was no statistically significant difference between human and virtual instructors, $F(1,110) = .031$, $p = 0.86$, and the interaction between type of instructor and emotion of instructor was not significant, $F(1,110) = 3.12$, $p = 0.08$. These results demonstrate that the participants who had happy instructors rated themselves as more happy than those who had bored instructors, and this effect was equivalent for human and virtual instructors.

The second row of Table 2c shows the mean ratings (and standard deviations) of the learner's level of content emotion (which is considered a positive emotion) for each of the four groups. Consistent with prediction 2 reflecting the positivity principle, the content rating was higher for learners who received the happy instructor (*M* = 3.52, *SD* = .96) than for those who received the bored instructor (*M* = 1.55, *SD* = .95), $F(1,110) = 118.56$, $p < 0.001$, $d = 2.06$. Consistent with prediction 5b reflecting the equivalence principle, there was no statistically significant difference for different types of instructors, $F(1,110) = .064$, $p = 0.80$, and no significant interaction and between type of instructor and emotion of instructor, $F(1,110) = 2.55$, $p = 0.11$. These results demonstrate that the participants who had happy instructors rated themselves as more content than those who had bored instructors, and this effect was equivalent for human and virtual instructors.

The third row of Table 2c shows the mean ratings (and standard deviations) of the learner's level of bored emotion for each of the four groups. Consistent with prediction 2 reflecting the positivity principle, the bored rating was higher for participants who received the bored instructor (*M* = 4.30, *SD* = 1.31) than for those who received the happy instructor (*M* = 2.48, *SD* = 1.11), $F(1,110) = 62.90$, $p < 0.00$, $d = 1.50$. Consistent with prediction 5b reflecting the equivalence principle, there was no statistically significant difference for type of instructors, $F(1,110) = .31$, $p = 0.58$, and no significant interaction type of instructor and emotion of instructor, $F(1,110) = 1.71$, $p = 0.19$. These results demonstrate that participants who had bored instructors rated themselves as more bored than those who had happy instructors, and this effect was equivalent for human and virtual instructors.

The fourth row of Table 2c shows the mean ratings (and standard deviations) of the learner's level of frustrated emotion (which is a negative emotion) for each of the four groups. Consistent with prediction 2 reflecting the positivity principle, the frustrated rating was higher for participants who received the bored instructor (*M* = 3.50, *SD* = 1.19) than for those who received the happy instructor (*M* = 1.79, *SD* = .95), $F(1,110) = 62.90$, $p < 0.001$, $d = 1.59$. In contrast to prediction 5b, for frustrated self-ratings, a statistically significant difference was found between different types of instructors, $F(1,110) = 4.93$, $p = 0.03$, indicating that the agent instructor led to greater frustration among participants than did the human instructor. The interaction between type of instructor and emotion of instructor was not significant, $F(1,110) = 3.23$, $p = 0.075$. These results demonstrate that the participants who had bored instructors rated themselves as more frustrated than those who had happy instructors, and this effect was equivalent for human and virtual instructors (although virtual instructors created more frustration overall).

In conclusion, the happy instructors elicited a happy (and content) feeling among participants, while the bored instructors elicited a bored (and frustrated) feeling among participants, showing that the emotion of the instructor led to the same kind of emotion in participants, which is the second step of the positivity principle. The equivalence principle was also supported in 3 of 4 tests.

Do the Groups Differ in Self-Ratings?

To determine whether the manipulations of the instructor's emotion or type of instructor had an effect on participants' motivation as per step 3 of the cognitive-affective model of learning with instructional video, measures of how participants rated motivational aspects of their learning experience were collected in the post-questionnaire. Table 2d shows the mean ratings (and standard deviations) of the four groups on how motivated they were to pay attention, how much they enjoyed the lesson, and how much they would like to have another similar lesson. Each rating was compared among the groups based on 2x2 analysis of variance, with type of instructor and type of emotion as factors.

The first row of Table 2d shows the motivation self-ratings for the four groups. Consistent with prediction 3 reflecting the positivity principle, the motivation rating was higher for participants who received the happy instructor (M = 3.50, SD = .98) than for those who received the bored instructor (M = 1.71, SD = .97), $F(1,110) = 99.76$, $p < 0.001$, d = 1.84. In line with prediction 5c reflecting the equivalence principle, there was no statistically significant difference between different types of instructors, $F(1,110) = .023$, $p = 0.88$, but this finding is qualified by a significant interaction between type of instructor and emotion of instructor, $F(1,110) = 10.85$, $p = 0.001$, in which the motivating effect of emotion was stronger for humans than for agents. These results show that the participants who had a happy instructor were more motivated than those who had a bored instructor, and the effect was stronger with human instructors than with virtual instructors.

As shown in the second line of Table 2d, the enjoyment rating was higher for participants who received the happy instructor (M = 2.84, SD = 1.25) than for those who received the bored instructor (M = 1.98, SD = .94), $F(1,110) = 16.44$, $p < 0.001$, d = 0.79, which supports prediction 3. Consistent with prediction 5c, there was no significant main effect of type of instructor, $F(1,110) = .71$, $p = 0.40$, and no significant interaction, $F(1,110) = 1.93$, $p = 0.17$. These results show that the participants who had a happy instructor found the lesson more enjoyable than those who had a bored instructor, and this effect was equivalent for human and virtual instructors.

As shown in the third line of Table 2d on ratings of wanting to have another lesson like this one, the rating was significantly higher for participants who received the happy instructor (M = 2.81, SD = 1.23) than for those who received the bored instructor (M = 1.50, SD = .91), $F(1,110) = 40.23$, $p < 0.001$, d = 1.21, which supports prediction 3 of the positivity principle. In line with prediction 5c, there was no statistically significant difference was between different types of instructors, $F(1,110) = .01$, $p = 0.93$, and the interaction between type of instructor and emotion of instructor was not significant, $F(1,110) = 2.81$, $p = 0.10$. These results show that the participants who had a happy instructor were more interested in having another similar lesson than those who had a bored instructor, and this effect was equivalent for human and virtual instructors.

Based on these results, we conclude that the happy group reported an overall greater level of motivation, interest, and enjoyment as compared to the bored group, which supports hypothesis 3 of the positivity principle. Hypothesis 5c also was supported in that the effects were similar for human and virtual instructors in 2 of 3 tests.

Do the Groups Differ in Their Learning Outcomes?

The final step in the cognitive-affective model of learning with instructional video is that the emotional state of the instructor affects the learning outcome. The mean scores on the posttest (and standard deviations) are shown in Table 2e. The posttest scores were compared among the groups based on 2x2 analysis of variance, with type of instructor and type of emotion as factors.

In contrast to prediction 4 of the positivity principle, no statistically significant difference was found between different types of instructors, $F(1,110) = .01$, $p = 0.95$. Consistent with prediction 5d reflecting the equivalence principle, there was no significant difference between the happy and bored instructor emotions, $F(1,110) = 1.13$, $p = 0.29$, and the interaction between type of instructor and emotion of instructor was not significant, $F(1,110) = 0.77$, $p = 0.38$.

These results show that the happy group did not have greater learning outcomes, compared to the bored group, which doesn't support hypothesis 4. One possible reason for this unexpected result is that an immediate test was used instead of a delayed test, which has been shown to be better for discerning deep learning effects (Roediger & Karpicke, 2006).

Discussion

Empirical Contributions

The main findings of this study are summarized in the rightmost column of Table 1, which show that the emotional state displayed by the instructor can be detected by the learner and affects the learner's emotional and motivational state. However, this study do not find that the emotional state displayed by the instructor affected learning outcome on an immediate test. Finally, the pattern of results generally was similar with human instructors and virtual instructors, although learners were better able to recognize emotions of humans than the emotions of onscreen agents. Overall, the results are consistent with the larger body of research on animated pedagogical agents showing that embodiment cues such as gesture and voice can influence motivation and learning (Mayer, 2020)

Theoretical Contributions

The results are consistent with 3 of the 4 predictions of the positivity principle, which states that people learn better with positive instructors than negative instructors. This pattern of results partially supports the cognitive-affective model of learning with instructional video summarized in Figure 1, including each step except the last one. It is possible that a delayed posttest would be more sensitive to differences caused by the instructor's emotional tone.

The results are consistent with most of the predictions of the equivalence principle, which states that the emotional tone of the instructor has the same effects for human and virtual instructors. Overall, learners responded similarly to the virtual instructor and the human instructor, except the emotions were more strongly recognized with human instructors. It is possible that the virtual agents need to be better designed to convey gestures as strongly as for humans.

Practical Implications

With the development of technology and schools currently switching to online teaching, video lectures may become the new norm. In this case, it’s important for the design of instructional video lessons to be as efficacious as possible. It is important for instructors to display a happy emotion, because doing so will help increase the positive emotion and motivation in students. In addition, it may also be important for human instructors to be maintained instead of switching to animated instructors, but more research is required to better understand how to design computer animated instructors that convey the same emotions as human instructors.

Limitations and Future Directions

One shortcoming of the current study was that the posttest was given to participants immediately after the video lesson. In some studies, differences in learning outcomes tend to become more pronounced in a delayed test (e.g., Roediger & Karpicke, 2006), so a delayed test could yield different results. Therefore, future research should employ a delayed test.

Furthermore, the agent used in the study only exhibited some human-associated mannerisms, so this may have weakened the efficacy of the agent in imitating a human instructor. This may explain why the participants better recognized emotion in the human instructor than in the agent instructor. More research comparing the efficacy of teaching between human and agent instructors would help shed light on a potential difference between the two forms of teaching, which would have implications on the design of agent-based instruction.

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Table 1a
Predictions of the Positivity Principle

Hypothesis	Measure	Prediction	Upheld
1	Rating of instructor's emotion	Main effect of instructor's emotion on rating of instructor's emotion	YES
2	Rating of learner's emotion	Main effect of instructor's emotion on rating of learner's emotion	YES
3	Rating of motivation	Main effect of instructor's emotion on rating of motivation	YES
4	Score on posttest	Main effect of instructor's emotion on posttest score	NO

Table 1b
Predictions of the Equivalence Principle

Hypothesis	Measure	Prediction	Upheld
5a	Rating of instructor's emotion	No main effect of type of instructor on rating of instructor's emotion	YES
		No interaction	NO
5b	Rating of learner's emotion	No main effect of instructor's emotion on rating of learner's emotion	YES
		No interaction	YES
5c	Rating of motivation	No main effect of instructor's emotion on rating of motivation	YES
		No interaction	YES
5d	Learning outcome	No main effect of instructor's emotion on posttest score	YES
		No interaction	YES

Table 2a

Mean Score (and Standard Deviation) on Prequestionnaire Items for Each Group

	Group							
	Happy Human		Happy Agent		Bored Human		Bored Agent	
Item	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Prior knowledge	1.80	0.89	1.70	0.98	1.75	1.00	1.62	1.06
Age	19.20	1.47	19.18	1.22	19.04	1.04	19.00	0.94

Table 2b

Mean Rating (and Standard Deviation) of the Emotional State of the Instructor for Each Group

	Group							
	Happy Human		Happy Agent		Bored Human		Bored Agent	
Rated Emotion	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Happy	4.17	0.91	3.96	0.92	1.27	0.83	1.96	1.22
Content	4.33	0.80	3.93	0.90	1.37	0.93	1.96	1.15
Bored	1.77	1.01	2.36	1.25	4.73	0.78	4.27	1.25
Frustrated	1.20	0.48	1.50	0.75	3.93	1.14	3.08	1.32

Table 2c

Mean Rating (and Standard Deviation) of Emotion Experienced by the Learner for Each Group

	Group							
	Happy Human		Happy Agent		Bored Human		Bored Agent	
Rated Emotion	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Happy	3.50	0.94	3.14	1.08	1.40	0.89	1.69	1.01
Content	3.63	0.93	3.40	0.99	1.40	0.85	1.73	1.04
Bored	2.40	1.04	2.57	1.20	4.50	1.14	4.08	1.47
Frustrated	1.83	0.95	1.75	0.97	3.87	1.11	3.08	1.16

Table 2d

Mean Self-Rating (and Standard Deviation) on Three Measures for Each Group

	Group							
Rating	Happy Human		Happy Agent		Bored Human		Bored Agent	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Motivation	3.77	.77	3.21	1.10	1.43	.86	2.04	1.00
Enjoyment	2.90	1.18	2.79	1.34	1.77	.82	2.23	1.03
Another Lesson	2.97	1.07	2.64	1.39	1.33	.61	1.69	1.16

Table 2e

Mean Posttest Scores (and Standard Deviation) for Each Group

	Group							
	Happy Human		Happy Agent		Bored Human		Bored Agent	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Scores	11.45	4.34	10.75	3.37	10.02	4.03	10.62	3.95

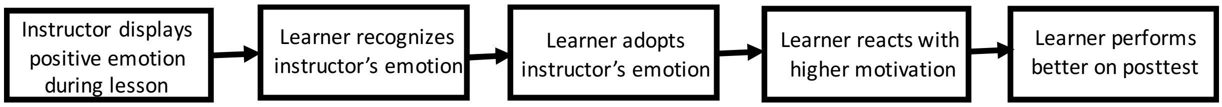

Figure 1. *Cognitive-Affective Model of Learning with Instructional Video*

Figure 2.

Screenshot of happy human instructor (top) and bored human instructor (bottom).

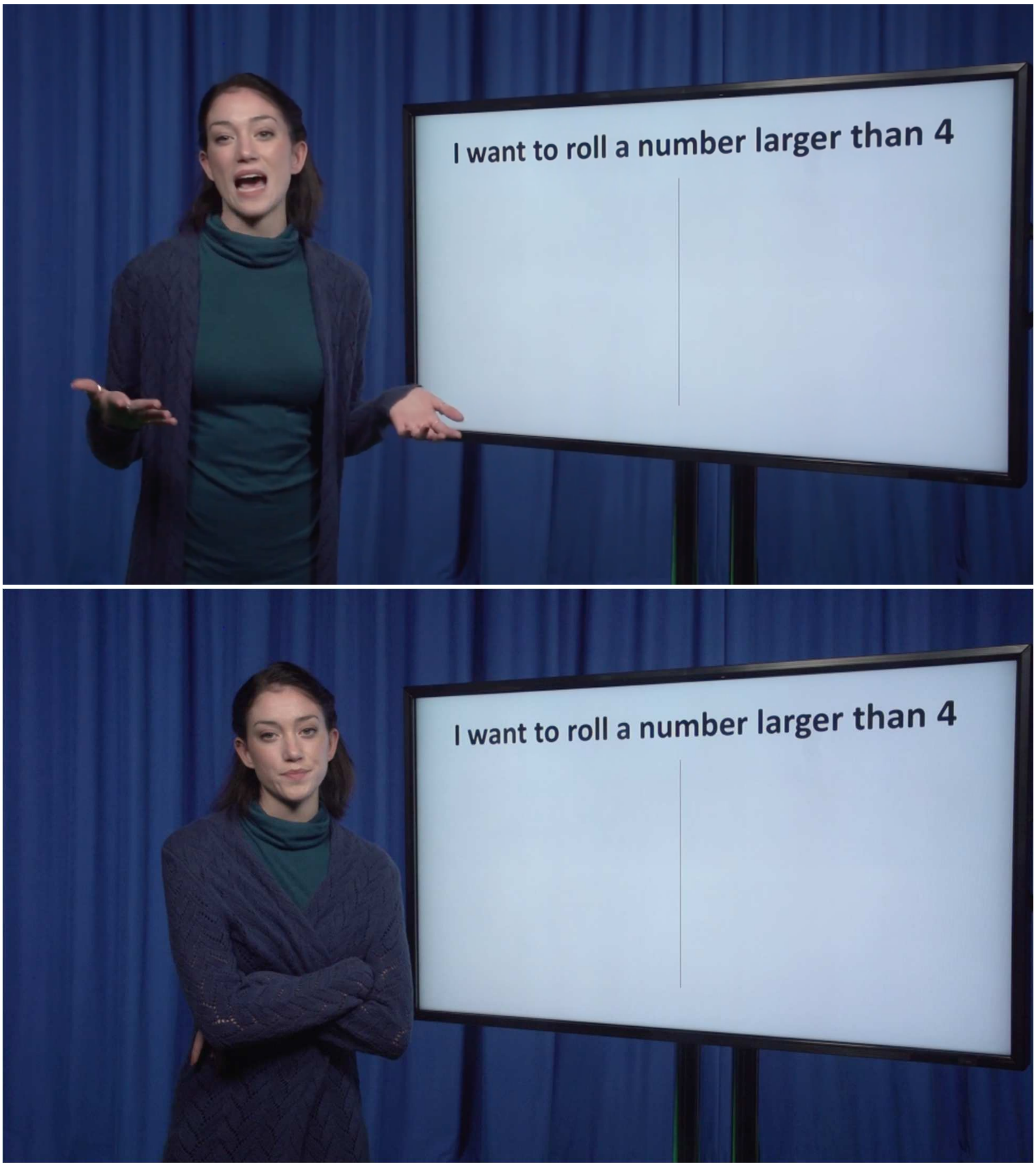

Figure 3.

Screenshot of happy virtual instructor (top) and bored virtual instructor (bottom). .

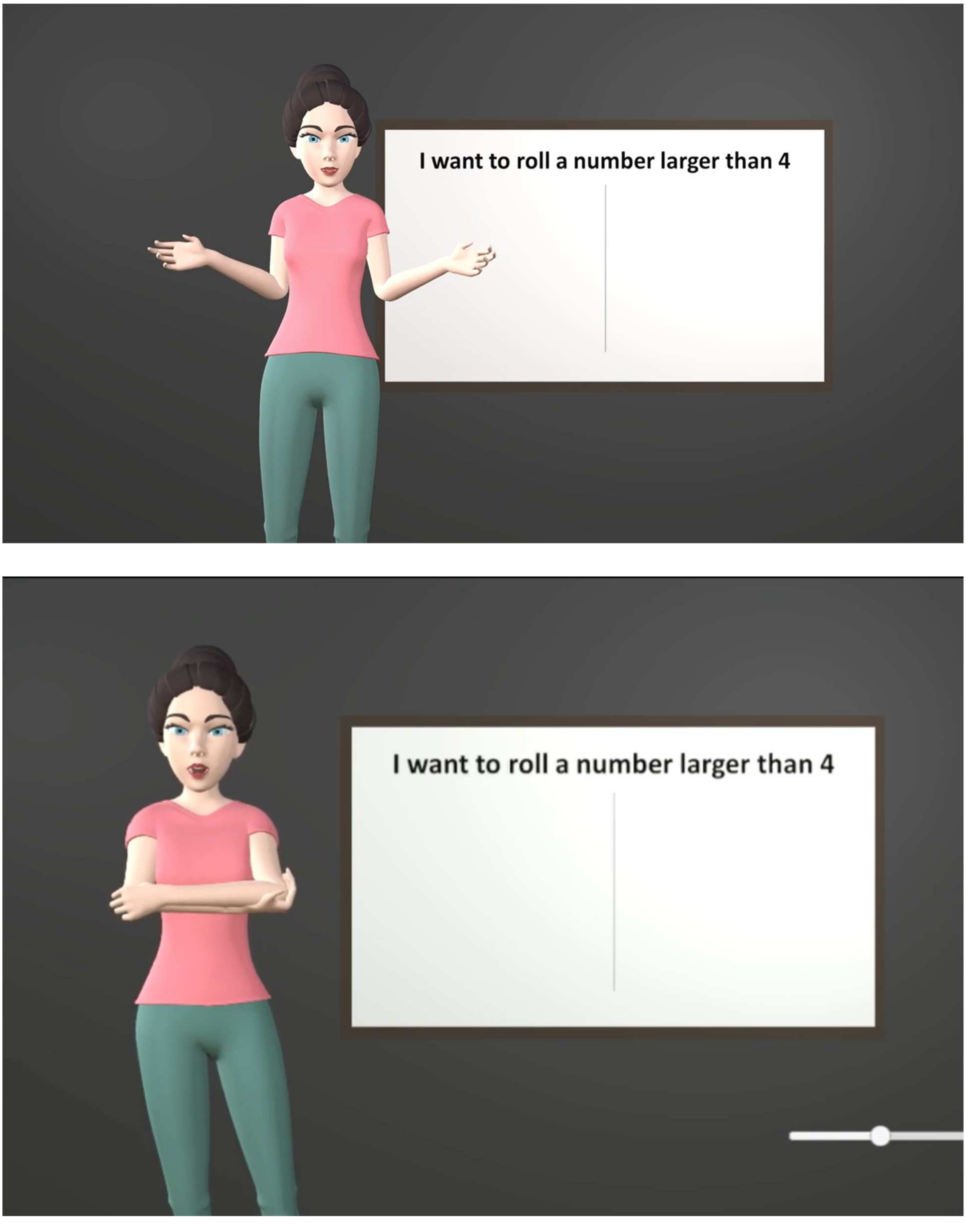

Figure 4. Mean Rating of the Emotional State of the Instructor for Each Group