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Using a pedagogical agent to deliver conversational style instruction: What benefits can you obtain?

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ABSTRACT

The purpose of the current study was to investigate the potential effects of two social cues on learning outcomes, cognitive load, and intrinsic motivation in a computer-based environment in an Asian context. A total of 98 Chinese college students were randomly assigned into one of four experimental conditions formed by a 2 (agent vs. no agent) X 2 (conversational style vs. formal style) factorial design. Results revealed that (a) learning with a pedagogical agent was more interesting than learning without a pedagogical agent; (b) learning from a lesson written in a conversational style enhanced retention but also resulted in increased pressure; and (c) a pedagogical agent delivering instruction in a conversational style led to an increase in mental effort, but instruction delivered in this style without a pedagogical agent led learners to perceive it as less difficult. These findings support the use of a pedagogical agent to deliver instruction in a conversational style to Chinese learners. But parsimonious instructional designs, such as a design to deliver instruction in a conversational style without an animated pedagogical agent, also have advantages under some circumstances, particularly when the learning materials are not so difficult and when advanced technology cannot be utilized or afforded.

1. Introduction

To enhance learning through human-computer interaction, researchers have argued for the utilization of social cues, including the incorporation of an animated pedagogical agent and the use of a conversational style in learning materials (Mayer, 2014). Learners may benefit from these social cues by treating the human-computer interaction as social events and applying human-to-human rules when communicating with the computer (Gratch, Wang, Gerten, Fast, & Duffy, 2007; Reeves & Nass, 1996; Zanbaka, Ulinski, Goolkasian, & Hodges, 2004), thus leading to enhanced learning. According to the *personalization principle* (Mayer, 2014), instruction presented in a conversational style rather than a formal style can enhance deep and meaningful learning. The available literature reveals a tendency showing a positive effect of instruction using a conversational style on learning outcomes (i.e., learners' performance on retention and transfer tests) (Ginns, Martin, & Marsh, 2013). However, the effect has rarely been tested in a multimedia learning environment embedded with an animated pedagogical agent (for an exception, see Moreno & Mayer, 2000). To fill this gap in the literature and to extend this effect to an Asian context, we conducted the current study to investigate whether utilizing two types of social cues together—a pedagogical agent delivering instruction in a conversational style —can further enhance learners' motivation, cognitive load, and learning outcomes.

Dependent Variable

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1.1. Theoretical perspectives of learning with animated pedagogical agents

A virtual agent is a lifelike character that has some or all of the following features: (a) a human-like look, (b) locomotion, (c) goal-directed gestures, (d) facial expression, (e) gaze, and (f) a human voice (Lin, Atkinson, Christopherson, Joseph, & Harrison, 2013). Computer science researchers have found from evaluation studies that users are very likely to treat a virtual agent as a real human in non-educational tasks, such as pattern recognition tasks (Zanbaka et al., 2004), story-narrating tasks (Gratch et al., 2007), or interviewing tasks (Lucas, Gratch, King, & Morency, 2014). Thus, users apply human-to-human interaction rules into the process of human-computer interaction (Bickmore, Gruber, & Picard, 2005).

In educational contexts, an animated pedagogical agent is a type of virtual agent that is embedded in a computer-based learning environment to deliver instruction through verbal and nonverbal forms of communication. From the social agency theory perspective, some researchers argue that learners may be triggered by the diverse verbal and non-verbal social cues provided by a pedagogical agent (Mayer, Sobko, & Mautone, 2003; Moreno, Mayer, Spires, & Lester, 2001). These learners would assume that their relationship with the computer is a social one, similar to communicating with a teacher or a peer (Atkinson, Mayer, & Merrill, 2005; Kim & Baylor, 2006; Louwerse, Graesser, Lu, & Mitchell, 2005). As a result, they may put more effort into interacting with the pedagogical agent and the presented learning materials in order to make sense of them. This socialization can lead to their enhanced learning (Atkinson, 2002).

From the perspective of self-determination theory, an individual's motivation can be categorized into intrinsic (i.e., doing something due to inherent interest) or extrinsic (i.e., doing something that leads to separate outcomes) (McAuley, Duncan, & Tammen, 1989; Ryan & Deci, 2000; Ryan, Koestner, & Deci, 1991). Intrinsic motivation is multidimensional, with interest as its core element, competence and value as its positive aspects, and pressure as its negative aspect (Deci, Eghrari, Patrick, & Leone, 1994). Because of the verbal and non-verbal behaviors introduced by a pedagogical agent, learners' engagement in a computer-based environment embedded with an agent is not likely due to extrinsic reward or punishment (i.e., extrinsic motivation) (Dehn & van Mulken, 2000). Instead, their engagement is probably due to their established social bond with the pedagogical agent, resulting in heightened interest and enjoyment, as well as increased value and decreased pressure (i.e., intrinsic motivation) (Krämer & Bente, 2010). Therefore, in addition to the potential cognitive benefits on learning, a pedagogical agent in a computer-based environment may also have positive impacts on learners' intrinsic motivation.

Notwithstanding these potential benefits, it is also possible that a pedagogical agent may prevent students from learning. Cognitive load theory provides a theoretical lens to explain this alternative. According to current formulations of cognitive load theory (Sweller, Ayres, & Kalyuga, 2011), there are two distinct types of cognitive load that can be imposed on learners' working memory. The first type is extraneous cognitive load, which is caused by inappropriate instructional format. This load does not contribute to schema construction and thus needs to be minimized. The second type is intrinsic cognitive load, which is determined by the inherent complexity of a learning task or material in relation to the learner's prior knowledge. From that perspective, a pedagogical agent can become a source of extraneous cognitive load, if it displays irrelevant gestures, gaze, facial expressions or locomotion. Learners may be overloaded and consequently pay insufficient attention to the learning material due to the extraneous cognitive load caused by an appealing but distracting pedagogical agent (Clark & Choi, 2005). Being seductive and of little relevance to learning (c.f., seductive details effect, Harp & Mayer, 1998; Rey, 2012), an unsuitably designed pedagogical agent might thus prevent learners from constructing appropriate schemas of the presented information.

1.2. Empirical evidence of learning with animated pedagogical agents

The literature tends to be mixed with respect to whether visually presenting a pedagogical agent can have positive effects on learning. In a systematic review based on 26 relevant articles published from 2002 to 2009, Heidig and Clarebout (2011) found that 15 studies compared a pedagogical agent condition to a no-agent condition. The majority of them demonstrated a non-significant effect of a pedagogical agent on learning outcomes or learner motivation. Schroeder, Adesope, and Gilbert (2013) conducted a meta-analysis that included 43 studies. Their finding, which revealed a small, positive effect of a pedagogical agent on learning, was also not promising. Furthermore, both the meta-analysis and the systematic review pinpointed a number of significant moderators, such as the modality of instruction, the subject domain, and the educational level, which is consistent with the mixed findings in the literature.

Specifically, some research has demonstrated an image effect: the visual presence of a pedagogical agent can enhance learning (e.g., Atkinson, 2002; Chen & Chou, 2015; Moreno et al., 2001). For instance, Atkinson (2002) designed an animated parrot to deliver worked-example instruction about proportion-word problems. He found that individuals studying the material with the pedagogical agent performed significantly better on learning outcomes than their counterparts studying the same material without such an agent. A few empirical studies have even shown that a human voice of a pedagogical agent can also have benefits on learning (Atkinson et al., 2005; Louwerse et al., 2005; Park, 2015).

However, there is also research showing mixed findings or no impact of including a pedagogical agent (e.g., Chen, 2012; Choi & Clark, 2006). For example, a follow-up study of Atkinson (2002), in which the same parrot agent was used, revealed mixed results (Lusk & Atkinson, 2007). The learners who learned from worked examples embedded with a static pedagogical agent without gaze and locomotion had better performance on practice problems than their peers who learned from worked examples. In addition, an animated pedagogical agent with gaze and locomotion enhanced near and far transfer performance. A similar styled pedagogical agent was also evaluated in a more recent study (Chen, 2012), where the goal was to teach Chinese idioms. He found that this pet-styled animated pedagogical agent did not enhance elementary school students' learning.

Regarding the motivational effects of pedagogical agents, only a limited number of early studies measured motivation (Baylor & Kim, 2005; see Heidig & Clarebout, 2011 for a review), but recent findings seem to be promising (e.g., Chen & Chou, 2015; Dinçer & Doğanay, 2017; Park, 2015). For instance, Park (2015) utilized a multimedia environment to deliver a lesson about intellectual property to college students enrolled in a computer literacy course. His study revealed that a pedagogical agent with a human voice explaining the content not only reduced learners' cognitive load, but also increased their interest. In addition, Baylor and Kim (2005) found that only those pedagogical agents with expressive gestures and emotions had positive impacts on learners' motivation, whereas those with limited gestures and authoritative tones enhanced learning but not motivation.

In terms of the effects of pedagogical agents on cognitive load, existing literature is inconclusive. Some studies did not measure cognitive load (e.g., Baylor & Kim, 2009; Mayer & DaPra, 2012; Moreno & Mayer, 2000), whereas other studies measured perceived difficulty (e.g., Dinçer & Doğanay, 2017; Moreno et al., 2001) or mental effort (e.g., Choi & Clark, 2006; Park, 2015) as evidence of cognitive load. For those studies that did measure cognitive load, the results are even more mixed. For instance, Moreno et al. (2001) found no significant difference on perceived difficulty between the condition with a pedagogical agent and the condition without a pedagogical agent. However, Dinçer and Doğanay (2017) found that learning with a pedagogical agent reduced overall cognitive load.

In summary, empirical evidence regarding the effects of a pedagogical agent on learning, motivation, and cognitive load is somewhat ambiguous. One approach is to let the pedagogical agent deliver conversational style instruction to directly address the learner in order to foster active cognitive processing (Mayer, 2014), although there are other possible solutions (e.g., Li, Wang, Mayer, & Liu, 2019).

1.3. Instruction in a conversational style

Research on designing lessons with a conversational style has operationalized conversational style in several ways. The primary way is to change text to emphasize first- or second-person forms of address (e.g., “you” and “your”) rather than third-person forms (e.g., “the”). In addition, some studies include comments directed to learners, such as “*Now we know what will happen to our smallest star in the end.*” (Kartal, 2010) or “*Look at the picture!*” (Reichelt, Kämmerer, Niegemann, & Zander, 2014). As the both of the above redesigns relate the instructional material to the student, an individual who learns from it is more likely to become interested and engaged in the mental processing of the material (the self-reference effect, Klein & Loftus, 1988), thus resulting in improved learning. A number of empirical studies in the past two decades have looked into the effects of conversational style learning materials in a variety of domains and learning environments. For instance, Mayer, Fennell, Farmer, and Campbell (2004) asked college students to learn about the human respiratory system from a computer-based lesson. They designed a conversational style multimedia lesson where the audio narration used possessive pronouns and directly addressed learners (e.g., “your lungs”). They also designed a lesson in a formal language by replacing second person pronouns with impersonal articles (e.g., “the lung”). In three laboratory experiments, they found that the multimedia material presented in a conversational style promoted learners' transfer performance. However, the results of their study did not reveal a significant effect of the conversational language on learners' perceived interest. Moreno and Mayer (2000) tested the effect of using conversational style in a virtual game environment where an animated agent was embedded to provide instructional explanations about the relationship between plant features and environmental features. Not only did they find a positive effect of conversational style instruction on the retention test and the transfer test, but also on learners' perceived difficulty, friendliness, helpfulness, and physical presence. Specifically, learning from explanations in a conversational style reduced individuals' perceived difficulty, as well as increasing their perceived friendliness and physical presence.

Ginns et al. (2013) meta-analyzed 74 empirical studies from 1981 to 2012 that investigated the effect of a conversational style in designing instructional texts. Their findings revealed that textual materials in a conversational style had reliable positive effects on retention (small-to-medium effect) and transfer (medium effect) but not on perceived interest. Consequently, the role of interest in this effect is lacking empirical evidence, although it can be theorized that the increased level of interest enhanced by the conversational style material can lead to improved learning. Recent studies have been looking into this effect in a variety of domains and settings but the results are quite diverse. For instance, Reichelt et al. (2014) found that, if given a conversational style material from a psychology domain, learners were more motivated and had better retention than their peers who learned from materials using a formal style. But unlike those aforementioned studies conducted by Mayer and his colleagues (Mayer et al., 2004; Moreno & Mayer, 2004), this material did not enhance transfer. Riehemann and Jucks (2018) also used lesson material from psychology in their study. Interestingly, learners in their study benefited from the use of a conversational language style in terms of transfer. It is of note that the research by Riehemann and Jucks was conducted in a massive online open course (MOOC) environment, rather than in a research lab. Moreover, Dutke, Grefe, and Leopold (2016) presented a paper-based material, which is different from the above-mentioned empirical studies that tested this effect in computer-based environments. They utilized textual materials to teach German high-school students about the anatomy and functionality of the human eye. Their research showed that the textual material in a conversational style enhanced students' motivation and transfer. Other research addressing the effect of conversational style instruction has been conducted in learning astrophysics (Kartal, 2010), computer networks (Rey & Steib, 2013), and anatomy (Ginns & Fraser, 2010; Stiller & Jedlicka, 2010). However, according to the current literature, the positive effects on learners' motivation, retention, and transfer are still unclear.

A close examination of the literature suggests a number of factors that may influence the effect of conversational style instruction. One of these factors is learners' prior knowledge. In an empirical study conducted in German schools, Stiller and Jedlicka (2010) found an expertise reversal effect for learning from materials in a conversational style. To be specific, not only did the low-prior-knowledge individuals improve their drawing and labeling performance, but also their performance on a structural knowledge test

and transfer test. But this pattern did not exist for individuals with high prior knowledge; their structural knowledge was not affected and transfer performance was reduced, although the other two learning measures (i.e., drawing and labeling performance) improved. Another factor is the emotion induced by the material. If the content presents aversive topics, learners may not engage in the processing of the material that directly addressed to them. This argument is supported by the empirical studies conducted by Kühl and Zander (2017) and Zander, Wetzel, Kühl, and Bertel (2017). The instructional materials they used were about the skull of the human brain and brain damage. Their research revealed an inverted effect: materials in a conversational style were equivalent to or even worse than the materials in a formal style in terms of retention and transfer. Therefore, these two factors need to be controlled in research addressing the effect of conversational style instruction.

1.4. Overview of the study

The effect of conversational style instruction has mostly been tested on learners in English speaking countries (e.g., Ginns & Fraser, 2010; McLaren, DeLeeuw, & Mayer, 2011; Moreno & Mayer, 2000) and German speaking countries (e.g., Dutke et al., 2016; Riehemann & Jucks, 2018; Zander et al., 2017). The research investigating this effect has rarely been conducted in other cultural backgrounds, except in Czech and Turkish contexts (Brom, Hannemann, Starkova, Bromova, & Dechterenko, 2017; Kartal, 2010). The results of these latter two studies indicate that different cultures and languages may be a boundary condition for this effect, as their findings were inconclusive. Therefore, one purpose of the current study is to investigate whether the effect of conversational style instruction can be extended to an Asian culture, the Chinese culture in particular.

Another purpose of the current study is to further investigate the potential effects of two social cues, presence vs. absence of an animated agent and conversational vs. formal style of instructional text, on learning outcomes, cognitive load, and intrinsic motivation. We specifically considered learners' retention and transfer performance as learning outcomes because research reported in the literature is mixed regarding the effects on retention and transfer. In addition, both intrinsic motivation and cognitive load were incorporated as the dependent variables, as they are theoretically and empirically associated with the pedagogical agent effect and the effect of presenting instruction in a conversational style. Intrinsic motivation, a multidimensional construct, was assessed as four variables: interest, competence, value, and pressure (Deci et al., 1994). Theoretically, interest is the core of intrinsic motivation, whereas competence, value and pressure are different predictors of intrinsic motivation (Ryan et al., 1991). Despite the open question of how to measure cognitive load, self-reported mental effort and perceived difficulty were utilized in the current study as cognitive load measures (Brunken, Plass, & Moreno, 2011; De Jong, 2010; Sweller, 2017).

Specifically, the study addressed the following three research questions:

a) Does the visual presence of an animated pedagogical agent impact learning outcomes, cognitive load, and intrinsic motivation?
b) Does the learning material presented in a conversational style impact learning outcomes, cognitive load, and intrinsic motivation?
c) Does an animated pedagogical agent delivering instruction in a conversational style optimize learning outcomes, cognitive load, and intrinsic motivation?

2. Method

2.1. Participants & design

The participants consisted of 98 college students from a university in Shanghai, China. They were recruited from the psychology participant pool. The areas of study of the participating individuals were diverse, including psychology, education, computer science, physics, and law. Each individual was paid 30 RMB for their participation.

The study used a 2 × 2 between-subjects design; the first factor was the visual presence of an animated pedagogical agent (agent vs. no agent) and the second factor was the conversational-styled material (conversational style vs. formal style). All participants were randomly assigned into one of the four experimental conditions: (a) Agent/Conversational Style, (b) No Agent/Conversational Style, (c) Agent/Formal Style, and (d) No Agent/Formal Style.

Due to an internet connection problem, data from two individuals (both in the No Agent/Conversational Style condition) were not recorded. Therefore, the final sample consisted of 96 individuals with 24 in each condition. Their mean age was 21.14 years old (standard deviation = 2.19). Among them, 82 (85%) were females, which was quite representative for the university student population. In terms of their ethnicity, the majority (91 individuals) were from the Han ethnic group, and the remaining five individuals included one from the Hui ethnic group, one from the Kazakh ethnic group, one from the Tujia ethnic group, one from the Uyghur ethnic group, and one choosing not to report it.

2.2. Learning environments

The computer-based materials were composed of a multimedia lesson about the human cardiovascular system, specifically the function and structure of the human heart and blood. The learning environment consisted of 15 PowerPoint slides with the first two slides and the last slide presenting instructions regarding how an individual should proceed in the study, such as following a weblink to the demographic survey or using the two navigational buttons to go to the next slide or the previous slide. In the remaining 12 slides, static images with integrated text labels were used to present the content. Learners had the full control of their own pace.

In the two Formal Style conditions, audio narration that contained 1666 Chinese characters was delivered to learners in a formal

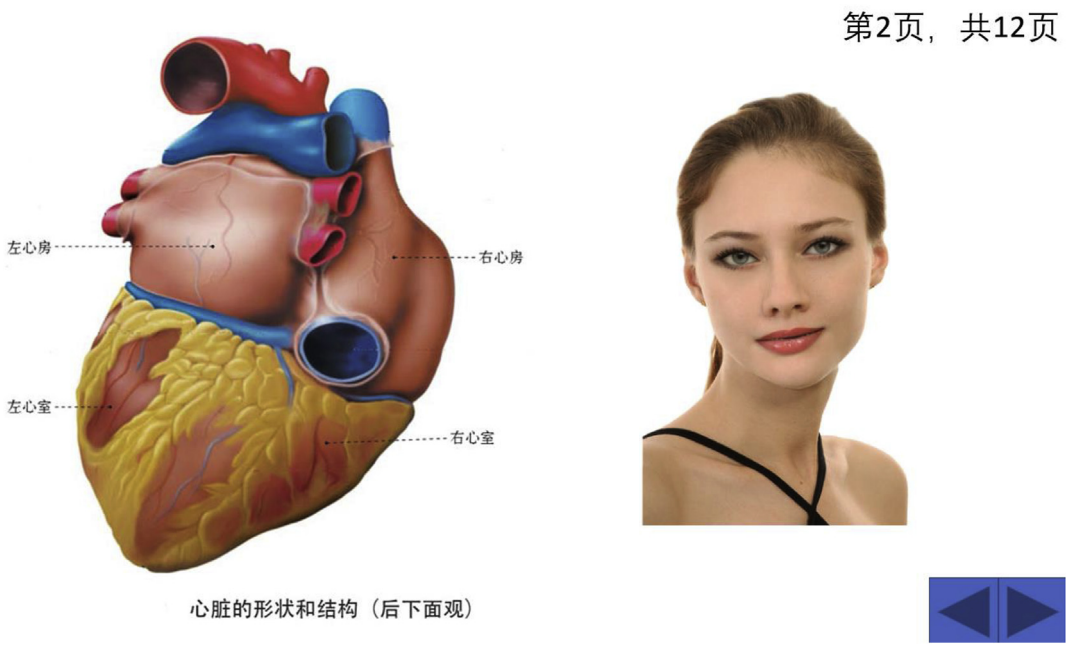

Fig. 1. A screenshot of the condition with a pedagogical agent.

style. For example, "The human heart is a muscle located between the lungs". The narration script was adapted from a previous study (Lin et al., 2017) and slightly modified to improve its cohesion. In the two Conversational Style conditions, the audio narration was presented in a conversational style. Specifically, 28 s person pronouns ("you" and "your"), along with seven short phrases directly addressing the learners ("Let me first introduce the structure of your heart to you."), were used. For example, "Your heart is a muscle located between your lungs". These minor changes resulted in a total of 1846 Chinese characters for the audio narration.

In the two Agent conditions, an animated female agent was embedded into each slide and displayed side by side with the static images (see Fig. 1). It was created using CrazyTalk© and exported into video files, which were inserted into PowerPoint. Through audio narration and lip synchronization, it provided verbal instructional explanations to learners. To avoid possible confounding, its facial expressions were controlled so that no emotions were expressed by the animated pedagogical agent (Kim, 2004; Liew, Zin, Sahari, & Tan, 2016). For the same reason, it had no body movement across the experimental conditions (Mayer & DaPra, 2012). In

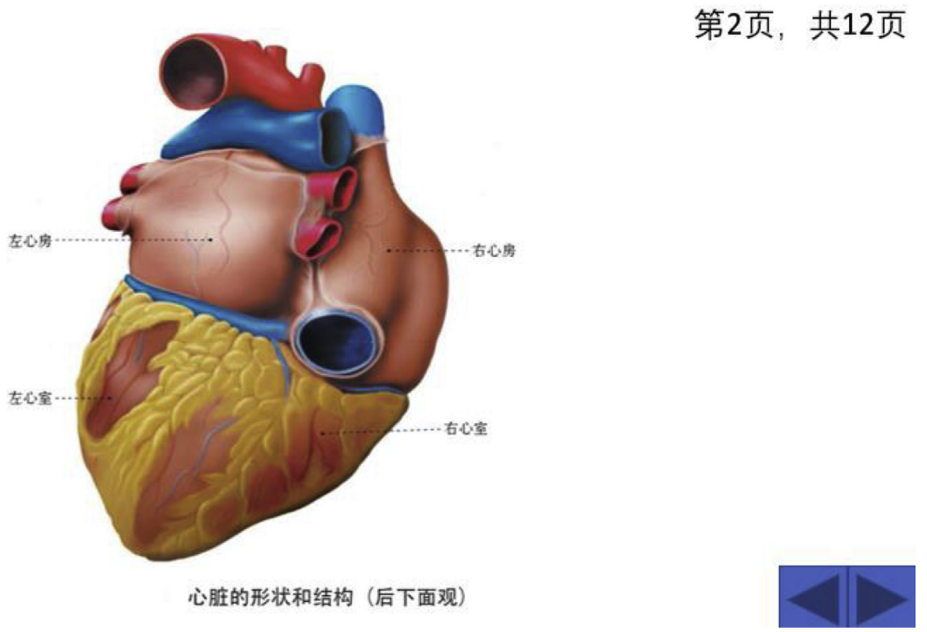

Fig. 2. A screenshot of the condition without a pedagogical agent.

the two No Agent conditions, only static images, accompanied with audio narrations, were presented on the PowerPoint slides (see Fig. 2). The voices of the audio narrations were identical across the four experimental conditions.

2.3. Measures & instruments

The instruments used in the study included a demographic survey, prior knowledge checklist, retention test, transfer test, cognitive load items, and intrinsic motivation items.

The demographic survey asked individuals' sex, age, ethnicity, and major. The prior knowledge checklist included three items, asking individuals to rate their knowledge about the human heart, the human blood, and the blood circulatory system on a 7-point Likert scale ranging from 1 ("*extremely unknowledgeable*") to 7 ("*extremely knowledgeable*"). The Cronbach's alpha for this self-report measure was 0.93. Each individual's prior knowledge score was computed by averaging their responses on these three items.

The retention test included 16 multiple-choice items (see Appendix). They were adapted from two previous studies (Lin et al., 2013, 2017) and had gone through minor changes of wording. Each test question had four choices—one correct answer and three distracters. An individual received zero points for each incorrect answer and one point for each correct answer. Therefore, a maximum of 16 points could be achieved. Cronbach's alpha for this test was 0.81.

Three open-ended questions, adapted from a previous study (Lin, Sun, Liao, Ren, & Zhao, 2019), were used as a transfer test. One point was awarded to each correct idea unit so that participants' written responses were transformed to quantitative data. A maximum of six points, eight points, and three points could be achieved for these transfer questions. Two authors, who were blind to the experimental conditions, independently coded 49 (51%) participants' responses. Cohen's Kappa was .90, .97, and 0.91 for the first, second, and third question. Therefore, one author coded the remaining responses. Each individual's transfer score was computed by combining their scores on these three items, and a maximum of 17 points could be achieved. Cronbach's alpha for this test was 0.61.

Following recent developments in cognitive load measurement (Krell, 2017; Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013), cognitive load was assessed by three self-report items: one was perceived difficulty and the other two were perceived mental effort. The difficulty item ("*It is easy to learn the content*") was adapted from the literature (Ayres, 2006; Kalyuga, Chandler, & Sweller, 1999). The mental effort items ("*I put a lot of effort into this*" and "*I didn't try very hard to do well at this activity*") were from Paas (1992) and Krell (2017). Each of these three items were administered on a 7-point Likert scale ranging from 1 ("*not at all true*") to 7 ("*very true*"). The negatively worded mental effort item was reverse-scored such that higher scores reflect higher mental effort invested by a learner. Each individual's mental effort rating was computed by averaging their responses on the two items so that the average and the two mental effort items were on the same scale (i.e., 1 to 7).

A total of 12 self-report items, adapted from McAuley et al. (1989) and implemented in Lin et al. (2013), were used to assess individuals' intrinsic motivation. This intrinsic motivation scale included four subscales—interest, competence, value, and pressure (see Table 1). Learners rated each item on a 7-point Likert scale ranging from 1 ("*not at all true*") to 7 ("*very true*"). The negatively worded items were reverse-scored such that higher scores reflect more positive motivation. Each individual's scores on interest, competence, value, and pressure were computed by averaging their responses on each of subscales. Cronbach's alphas for interest, competence, value, and pressure were .80, .75, 0.87, and 0.87 respectively.

All of these measures were administered through an online survey tool (www.wjx.cn).

2.4. Procedure

Field Research

The experiment was conducted in a controlled laboratory setting. First, each participant signed a consent form and was then seated in front of a Dell desktop computer. Next, a researcher informed participants about the goal and procedure of the experiment. Then, the researcher randomly assigned each individual to a condition with an experiment ID number. Experiment ID numbers were used to preserve the anonymity of each participant. Afterwards, participants started the experiment following the order of the demographic survey, instruction (with or without an agent delivering instruction in a conversational style or formal style), the retention and transfer test, and the self-report questionnaire assessing cognitive load and intrinsic motivation. Once the participants

Table 1
Intrinsic motivation items.

Item	Subscale
1. I would describe this learning task as very interesting.	Interest
2. I think I am pretty good at this learning task.	Competence
3. I believe this activity could be of some value to me.	Value
4. I did not feel nervous at all while doing this.	Pressure
5. I thought this was a boring activity.	Interest
6. I think I did pretty well at this activity, compared to other people.	Competence
7. I think that doing this activity is useful for understanding about the cardiovascular system.	Value
8. I was very relaxed in learning the content.	Pressure
9. I enjoyed the learning content very much.	Interest
10. I am satisfied with my performance at this learning task.	Competence
11. I believe doing this activity could be beneficial to me.	Value
12. I was anxious while working on this task.	Pressure

Table 2
Means and standard deviations of prior knowledge, learning outcomes, cognitive load, and intrinsic motivation.

	Agent						No Agent					
	Conversational Style (n = 24)			Formal Style (n = 24)			Conversational Style (n = 24)			Formal Style (n = 24)		
	M	SD	Adj. M	M	SD	Adj. M	M	SD	Adj. M	M	SD	Adj. M
Prior Knowledge	2.79	1.11		2.94	1.08		2.68	.91		2.79	1.24	
Retention[a]	11.50	2.65	11.50	10.21	2.65	10.15	11.25	2.36	11.30	10.50	2.57	10.50
Transfer[b]	4.83	2.04		4.83	1.52		4.88	1.65		4.92	1.98	
Difficulty	4.00	1.44		4.63	1.17		4.88	1.30		4.08	1.56	
Mental Effort	5.27	1.13		4.71	1.22		4.81	.91		5.21	1.05	
Interest	5.10	1.23		4.82	1.33		4.42	1.10		4.44	1.34	
Competence	3.94	1.44		4.13	.97		4.29	.89		4.10	.91	
Value	5.47	1.00		5.50	1.01		5.47	1.00		5.50	1.01	
Pressure	3.33	1.74		2.19	.98		2.78	1.27		2.42	.89	

Note. M = Mean. SD = Standard deviation. Adj. M = Adjusted mean.
[a] The maximum total of the knowledge retention test is 16.
[b] The maximum total of the transfer test is 17.

completed the experiment, they were thanked by the researcher and paid 30 RMB. The study was approximately 30 min in duration.

3. Results

Family-wise type I error rate was set at the 0.05 level. We used partial η^2 or Cohen's *d* as the effect size index. Accordingly, 0.01, 0.06, and 0.14 are considered as the η^2 values for small, medium, and large effect sizes, respectively, and 0.20, 0.50, and 0.80 are considered as the *d* values for small, medium, and large effect sizes (Cohen, 1988). Mean (M) and standard deviation (SD) are presented in Table 2.

3.1. Prior knowledge

A one-way analysis of variance (ANOVA) was conducted to evaluate whether individuals differed across the four experimental conditions. The results revealed that these individuals were equivalent in terms of prior knowledge, $F(3, 92) = 0.24$, $MSE = 1.19$, $p = .87$, partial $\eta^2 = 0.008$.

3.2. Retention

A 2 × 2 analysis of covariance (ANCOVA) was conducted. The first factor was the visual presence of a pedagogical agent (agent vs. no-agent); the second factor was the conversational style material (conversational style vs. formal style). The dependent variable was the retention score, and the covariate was the self-rating prior knowledge score. A preliminary analysis of the homogeneity-of-slopes assumption indicated that the relationship between the retention and the prior knowledge did not differ significantly as a function of the two independent variables (all $ps > .12$). The covariate, prior knowledge score, was also substantially correlated with the retention score, $r = 0.35$, $p < .001$. The ANCOVA showed a significant main effect of conversational style instruction, $F(1, 91) = 4.24$, $MSE = 6.47$, $p = .03$, partial $\eta^2 = 0.05$, indicating that individuals who learned from the material in a conversational style ($M = 11.38$, $SD = 2.49$) had better retention than their peers who learned from the material in a formal-style ($M = 10.35$, $SD = 2.59$). Neither the pedagogical agent main effect nor the interaction was significant, for the pedagogical agent main effect, $F(1, 91) = 0.02$, $p = .89$, partial $\eta^2 = 0.001$, for the interaction, $F(1, 91) = 0.29$, $p = .59$, partial $\eta^2 = 0.003$.

3.3. Transfer

A 2 (agent vs. no-agent) X 2 (conversational style vs. formal style) ANCOVA was planned to assess the effects of the two independent variables on transfer, controlling the effects of prior knowledge. A preliminary analysis of the homogeneity-of-slopes assumption indicated that the relationship between the transfer and the prior knowledge did not differ significantly as a function of the two independent variables (all $ps > .93$). However, the covariate (i.e., prior knowledge score) was also not substantially correlated with the transfer score, $r = 0.14$, $p = .16$. Therefore, a 2 (agent vs. no-agent) X 2 (conversational style vs. formal style) analysis of variance (ANOVA) was conducted. The results showed a non-significant pedagogical agent main effect, $F(1, 92) = 0.03$, $MSE = 3.27$, $p = .87$, partial $\eta^2 = 0.001$, a non-significant conversational style main effect, $F(1, 92) = 0.003$, $p = .96$, partial $\eta^2 = 0.001$, and a non-significant interaction, $F(1, 91) = 0.003$, $p = .96$, partial $\eta^2 = 0.001$.

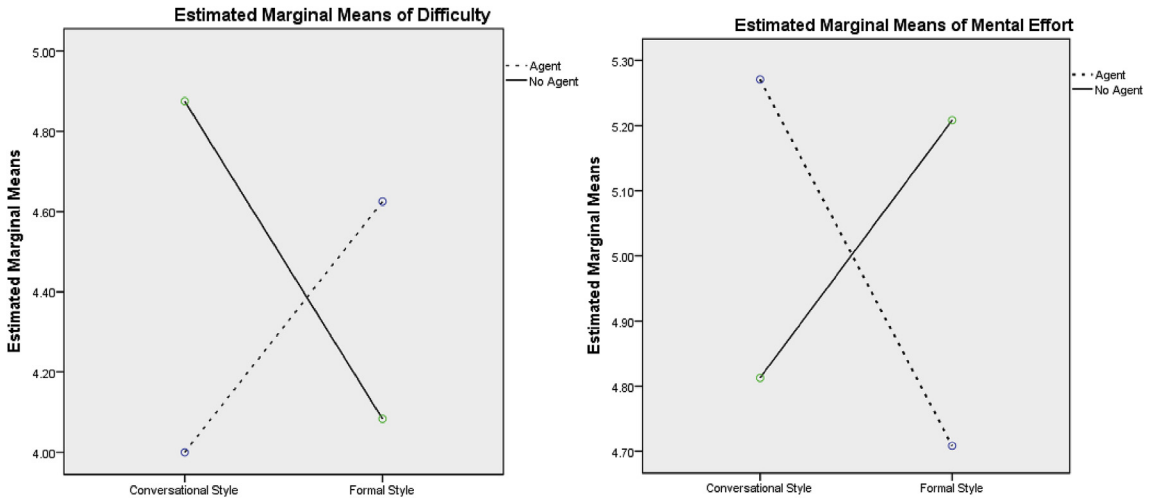

Fig. 3. Significant interactions on perceived difficulty and mental effort.

3.4. Cognitive load

A 2 (agent vs. no-agent) X 2 (conversational style vs. formal style) ANOVA was conducted to assess whether the use of a pedagogical agent presenting information in a conversational style had effects on learners' perceived difficulty. The results showed that neither the pedagogical agent main effect nor the conversational style main effect was significant; for the pedagogical agent main effect, $F(1, 92) = 0.35$, $MSE = 1.89$, $p = .55$, partial $\eta^2 = 0.004$, and for the conversational style main effect, $F(1, 92) = 0.09$, $p = .77$, partial $\eta^2 = 0.001$. However, there was a significant interaction effect, $F(1, 92) = 6.36$, $p = .01$, partial $\eta^2 = 0.07$ (see Fig. 3). Simple main effect analysis using the least significant difference (LSD) procedure further demonstrated a conversational style effect when an animated pedagogical agent was not present, $p = .049$, Cohen's $d = 0.55$, indicating that individuals who learned from the conversational style material without a pedagogical agent perceived the material significantly easier than their peers who learned from the formal style material without a pedagogical agent. But when the pedagogical agent was present, this conversational style effect disappeared, $p = .12$. In addition, pairwise comparisons from simple main effect analysis demonstrated a pedagogical agent effect when the conversational style material was provided, $p = .03$, Cohen's $d = 0.64$. However, when the material was in formal style, there was no pedagogical agent effect, $p = .18$.

A 2 (agent vs. no-agent) X 2 (conversational style vs. formal style) ANOVA was conducted to assess whether the use of a pedagogical agent presenting information in a conversational style had effects on learners' perceived mental effort. The results showed that neither the pedagogical agent main effect nor the conversational style main effect was significant, for the pedagogical agent main effect, $F(1, 92) = 0.009$, $MSE = 1.17$, $p = .93$, partial $\eta^2 = 0.001$, for the conversational style main effect, $F(1, 92) = 0.14$, $p = .71$, partial $\eta^2 = 0.002$. Similar to the findings revealed in the perceived difficulty, the results also demonstrated a significant interaction effect, $F(1, 92) = 4.70$, $p = .03$, partial $\eta^2 = 0.05$ (see Fig. 3). Simple main effect analysis using the LSD procedure demonstrated that, when the animated pedagogical agent was present, individuals who learned from the conversational style material reported higher mental effort than their peers who learned from the formal-style material, $p = .05$, Cohen's $d = 0.48$.

3.5. Intrinsic motivation

A series of 2 (agent vs. no-agent) X 2 (conversational style vs. formal style) ANOVAs were conducted to determine the effects of the pedagogical agent presence and the conversational style material on the four intrinsic motivation subscales—interest, competence, value, and pressure. The results demonstrated that there was a significant main effect of conversational style on pressure, $F(1, 92) = 8.43$, $p = .005$, partial $\eta^2 = 0.08$, indicating that learners who learned from conversational style material ($M = 3.06$, $SD = 1.53$) experienced significantly higher pressure than their peers who learned from formal-styled material ($M = 2.31$, $SD = 0.93$). Moreover, the ANOVA revealed a significant pedagogical agent main effect on interest, $F(1, 92) = 4.25$, $p = .04$, partial $\eta^2 = 0.04$, indicating that learners in the Agent conditions ($M = 4.96$ $SD = 1.28$) rated significantly higher on interest than their peers in the No Agent conditions ($M = 4.43$, $SD = 1.21$). Other main effects and interaction effects were all non-significant, all $Fs < 2.27$, all $ps > .14$.

4. Discussion & conclusion

The purpose of the current study was to investigate the potential effects of two social cues, a pedagogical agent delivering conversational style instruction, on learning outcomes, intrinsic motivation, and cognitive load. Alongside these goals, we examined whether the findings regarding the two social cues reported in mostly European language contexts could be extended to the Chinese

context. Our analyses revealed the following significant findings: (a) learning with an animated pedagogical agent was more interesting than learning without a pedagogical agent; (b) learning from a lesson presented in a conversational style enhanced retention but also resulted in increased pressure; and (c) a pedagogical agent delivering instruction in a conversational style led to increased mental effort; but instruction delivered in this style without a pedagogical agent led learners to perceive it as less difficult. We offer detailed discussions below.

Researchers have long argued, from the social agency theory perspective, that incorporating an animated pedagogical agent providing a variety of social cues in a computer-based environment can potentially enhance learning and motivation (Atkinson et al., 2005; Mayer et al., 2003). Surprisingly, only recently have studies provided somewhat consistent findings to support the motivational effect of a pedagogical agent (e.g., Chen & Chou, 2015; Dinçer & Doğanay, 2017; Park, 2015). Our research successfully replicated the positive pedagogical agent effect on interest reported in the literature, which provides support for the motivational effect delineated by social agency theory. However, we did not find any significant agent main effects on retention or transfer in the current study. This could be due to the design features of the pedagogical agent, such as gestures (Li et al., 2019), gender (Ozogul, Johnson, Atkinson, & Reisslein, 2013), or ethnicity of the pedagogical agent (Behrend & Thompson, 2011; Moreno & Flowerday, 2006). To be specific, the animated pedagogical agent used in our study did not involve any hand gestures pointing to the important information on the static pictures. Consequently, learners may have had difficulty building connections between the narration and the static pictures, which explains why learning outcomes (retention and transfer) were equivalent between the Agent conditions and the No Agent conditions. Moreover, our pedagogical agent was a young Caucasian female, which did not exactly match the surface-level characteristics of the participating learners in our study, who were predominantly young Asian females. This may lead to possible distractions (Behrend & Thompson, 2011; Moreno & Flowerday, 2006), which may explain the non-significant results. Future research can further investigate these design features of a pedagogical agent.

Contrary to the results revealed in a meta-analysis study conducted by Ginns et al. (2013), our results only revealed a positive effect of using a conversational style material on retention. Specifically, instruction presented in a conversational style fostered retention but not transfer, which is consistent with a number of empirical studies reported in the literature (e.g., Ginns & Fraser, 2010; Kartal, 2010; Reichelt et al., 2014; Zander et al., 2017). It could be possible that learners' emotional states when learning from the conversational style material plays a significant role, which previous theories and empirical studies have not taken into account. In fact, our study did suggest the role of emotion. In particular, we found that learners in the conversational style conditions experienced higher pressure than their peers in the formal style conditions. This pressure imposed on learners may induce negative emotions, such as anxiety, preventing them from actively constructing schemas (Plass & Kalyuga, 2019). As a result, learners' transfer performance may not be enhanced, even though they can recall information presented in the conversational style material. However, it is of note that the self-report pressure measures utilized in the current study was not intended to assess learners' emotion. Therefore, in future studies, researchers could consider adding real-time measures to assess emotions during learning (Harley, Bouchet, Hussain, Azevedo, & Calvo, 2015) or experimentally manipulate learning materials to induce learners' emotion (Plass et al., 2019).

In terms of the perceived difficulty and mental effort (indications of cognitive load), our findings indicate the advantages of jointly using an animated agent and conversational style designs because this leads to increased mental effort. Based on our findings, when an animated pedagogical agent is visually present in the multimedia learning environment, learners are more likely to be interested in interacting with the material. If the learning material directly addresses the learners, they may feel that learning is more relevant to themselves and thus invest more mental effort in learning the material. However, when an agent is not present, conversational style material is sufficient to influence learners' cognitive load because they can perceive the learning material as easy to learn. The findings regarding cognitive load in the current study significantly contribute to the existing literature for two reasons. First, Moreno and Mayer (2000), the only study that addressed the pedagogical agent effect and the effect of conversational style instruction, did not measure cognitive load, even though their study showed empirical evidence on retention and transfer. Second, our study indicates that a variety of social cues presented in the multimedia learning environment can positively impact cognitive load of Chinese learners, a cultural context that has not been thoroughly explored.

The findings of our study have theoretical and practical implications. First, social agency theory can predict the effect on learners' interest brought by a pedagogical agent. But this motivational effect can lead to cognitive benefits only when one or some of the agent's features, such as the language style investigated in the current study, are optimally designed. Otherwise, a pedagogical agent is merely entertaining and thus potentially distracting, resulting in non-significant or even negative impacts to learners, which can be predicted by cognitive load theory. Second, parsimonious instructional designs, such as a design to deliver conversational style instruction without an animated pedagogical agent, also have advantages under some circumstances, particularly when the learning materials are not so difficult and when advanced technology cannot be utilized or afforded. Instructional designers should take into account a variety of factors when making their design decisions. Third, the efficacy of using a conversational style, which has been demonstrated mostly in western cultures, can be extended to the Chinese context on the condition that it is better to be accompanied with a pedagogical agent.

The current study also has limitations. First, considering the effect sizes revealed from the analysis, the sample size we obtained may not be sufficiently large. Second, the participating learners were quite homogeneous in terms of gender and ethnicity. Caution should be taken when generalizing the findings revealed from the current study. Future research may need to further investigate the potential effects of these two variables. Third, we were unable to measure specific types of cognitive load due to the ongoing measurement issues in field of cognitive load theory (De Jong, 2010; Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Schnotz & Kürschner, 2007; for a more recent discussion, see; Zheng, 2017). Therefore, we were limited to measuring cognitive load only through assessing mental effort and perceived difficulty.

In summary, our current research empirically tested the effects of two social cues, an animated agent and learning material

written in a conversational style, in a multimedia environment. Our results contribute to understanding the cognitive and motivational benefits of incorporating these designs, separately or in concert, in computer-based lessons for Chinese students.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compedu.2019.103658.

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