Instructors’ pointing gestures improve learning regardless of their use of directed gaze in video lectures

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Abstract

Empirical research to date has not distinguished the effects of the instructor's pointing gestures from directed gaze in video lectures. This study tested the hypothesis that the pointing gesture is superior to directed gaze in enhancing video lecture learning. Participants (n = 120) watched one of four types of video lecture in which the instructor either (a) looked straight into the camera with no gaze shift and without pointing gesture; (b) made occasional gaze shifts and without pointing gesture; (c) looked straight into the camera with no gaze shift and pointed to the relevant areas of the slide; or (d) made occasional gaze shifts accompanied by pointing gestures towards the slides. ANOVAs found that students in the conditions that included the instructor's pointing gesture showed better learning performance, more efficient visual search, and greater attention to the learning content that the instructor was referring to, regardless of her use of directed gaze. The implication for education is that instructors should use pointing gestures, with or without directed gaze, to guide students' attention and improve their learning in video lectures.

1. Introduction

Suppose an instructor wants to use a video lecture to explain how creatures reproduce and clone, but the students lack relevant prior knowledge. As information is presented on the slides and then disappears, it is crucial for students to effectively visually search for what is relevant to the topic. What can the instructor do to improve students' visual search and potentially improve their learning performance? The instructor might use pointing gestures to guide students' visual attention to the learning content that they are referring to. Pointing gestures indicate objects or locations in a shared physical environment, typically made with an extended finger or hand (e.g., pointing to a flower in the vase to indicate that flower; Goldin-Meadow, 2014; McNeill, 1992).

Can an instructor's pointing gestures help students learn? Previous research has shown that when the instructor used pointing gestures, students paid greater attention to the learning content and learned more (Koumoutsakis, Church, Alibali, Singer, & Ayman-Nolley, 2016; Moreno, Reislein, & Ozogul, 2010; Pi, Hong, & Yang, 2017; Rueckert, Church, Avila, & Trejo, 2017). For example, in a study by Pi et al. (2017), participants viewed a video lecture about adjustment of curve in Photoshop. The researchers compared the attention allocation and learning performance of participants who viewed the video lecture with and without the instructor's pointing gestures.
gestures. When the instructor used pointing gestures, the participants looked longer at the relevant learning content and showed better learning performance.

In most of the studies investigating the effect of the instructor's pointing gestures, including the one just discussed, the researchers did not distinguish the effect of the instructor's pointing gestures from the effect of directed gaze (Pi et al., 2017; Rueckert et al., 2017). The instructor's directed gaze in a video lecture refers to the instructor shifting his or her gaze from the camera to the learning content being talked about (van Wermeskerken & van Gog, 2017). There is a difference between an instructor looking straight into the camera while producing pointing gestures and an instructor looking straight at the learning content on the slide while producing pointing gestures (Ouwehand, van Gog, & Paas, 2015). In the first condition, the instructor guides the students with pointing gestures, whereas in the second condition, the instructor not only uses pointing gestures but also uses directed gaze to guide students.

Both the instructor's pointing gestures and directed gaze accompany speech to produce social cues that are an integral part of teaching, even in video lectures (Ouwehand et al., 2015). However, recent studies on the role of the instructor's directed gaze in video lectures (Ouwehand et al., 2015; van Gog, Verver, & Verver, 2014; van Wermeskerken & van Gog, 2017) showed that the instructor's directed gaze effectively improved students' attention to the areas of the slide that the instructor was referring to, but did not improve students' learning performance. Therefore, we assume that the instructor's pointing gesture might be superior to directed gaze in enhancing video lecture learning.

Despite the null findings with regard to the effects of directed gaze on learning performance, several instructional design theories, such as Mayer's cognitive theory of multimedia learning (CTML) and Sweller's cognitive load theory (CLT), posit that both pointing gesture and directed gaze should improve learning (Mayer, 2005; Sweller, 1988). Both theories stress that students' working memory capacity is limited, with the result being that they can allocate their attention only to a small portion of incoming information at once (Baddeley, 1992). The implication is that video lectures should be designed to reduce extraneous processing, such as visual search on the screen for the content that the instructor is referring to, especially if the information shown on the screen is transient. Adding pointing gestures and directed gaze in video lectures might reduce students' extraneous visual search, as they guide students' attention to the key information (Ouwehand et al., 2015; Pi et al., 2017; van Wermeskerken & van Gog, 2017). Therefore, students do not waste limited cognitive capacity on unnecessary visual searches, and they will be able to engage in the cognitive processing needed for learning; namely integrating the instructor's oral explanation and visual information into a coherent mental model.

Although previous studies provided evidence of the potential benefits of the instructor's pointing gestures in video lectures, they did not distinguish the effect of the instructor's pointing gestures from the effect of his or her directed gaze (Pi et al., 2017; Rueckert et al., 2017). Furthermore, these studies tested students' visual attention based on dwell time or percentage dwell time (Ouwehand et al., 2015; van Wermeskerken & van Gog, 2017), which are believed to reflect the time used to process information (Holmqvist et al., 2011); however, these measures cannot detect whether the instructor's pointing gesture and directed gaze guide students' attention to the target area at the appropriate time. First fixation time may be a useful measure of the timeliness of the visual search (Yan et al., 2013). First fixation time refers to the point in time when the participant first looked at the specific area of interest; the shorter the first fixation time, the greater the efficiency of the visual search. Therefore, we tested the effects of the instructor's pointing gestures and directed gaze on attention as assessed by both first fixation time and percentage dwell time.

The current study tested the effects of the instructor's pointing gesture and directed gaze in a video lecture by measuring students' learning performance (retention and transfer) and attention. Participants watched a video lecture showing an instructor verbally explaining the topic of creature reproduction and cloning in one of four conditions: the instructor looking straight into the camera without pointing gestures (no social cues condition), making occasional gaze shifts toward relevant areas of the slide without pointing gestures (directed gaze condition), looking straight into the camera and pointing to the relevant areas of the slide that they were referring to (pointing gesture condition), or making occasional gaze shifts accompanied by pointing gestures toward the slides (directed gaze + pointing gesture condition). Based on CTML, CLT, and previous studies, we formulated the following hypotheses:

(1) Students in the directed gaze + pointing gesture condition would show the best retention, followed by students in the pointing gesture condition, students in the directed gaze condition, and finally students in the no social cues condition.

(2) Students in the directed gaze + pointing gesture condition would show the best transfer, followed by students in the pointing gesture condition, students in the directed gaze condition, and finally students in the no social cues condition.

(3) Students in the directed gaze + pointing gesture condition would show most efficient visual search, as indicated by first fixation time to the learning content that the instructor was referring to, followed by students in the pointing gesture condition, students in the directed gaze condition, and finally students in the no social cues condition.

(4) Students in the directed gaze + pointing gesture condition would pay more visual attention, as indicated by percentage dwell time on the learning content that the instructor was referring to, followed by students in the pointing gesture condition, students in the directed gaze condition, and finally students in the no social cues condition.

2. Method

2.1. Participants and design

Participants were 120 undergraduate and graduate students (27 males and 93 females) recruited from a Chinese university via advertisements posted on bulletin boards in the main teaching buildings. Their ages ranged from 17 to 35 years old ($M = 21.25$, $SD = 2.52$). Based on information that they provided in an informal interview before the experiment, participants had a wide range of majors (e.g., psychology, chemistry, history), but none were familiar with the topic presented in the video lecture. We ensured that
all participants had normal hearing by testing whether they could accurately report words played at 60 dB via computer speakers at a listening distance of 2 m. We also ensured that all participants had normal or corrected-to-normal vision, based on a simple vision test (read the open direction of the letter E on an eye chart). All participants provided written informed consent and received a small present for participating. The study protocol was approved by the local ethics committee.

Participants were randomly assigned to one of the following four video lecture conditions: (a) no social cues condition \((n = 30)\); (b) directed gaze condition \((n = 30)\); (c) pointing gesture condition \((n = 30)\); and (d) directed gaze + pointing gesture condition \((n = 30)\).

### 2.2. Apparatus

Eye movements were recorded using an Eyelink 1000 eye tracker (SR Research Ltd., Canada). Participants completed a 9-point calibration and validation procedure prior to viewing the video lecture. The stimuli were presented on a 21-inch CRT monitor with a viewing distance of 60 cm. The resolution of the monitor was \(1024 \times 768\) pixels, and the refresh rate was 75 Hz. Participants listened to the lecture via headphones connected to the computer. Data were monitored at a 1000 Hz monocular sampling rate.

### 2.3. Materials

#### 2.3.1. Video lectures

Four conditions of a video lecture (identical except for the use of pointing gestures and directed gazes) were used. The lecture was on how creatures reproduce and clone, and it lasted approximately 8 min and 40 s. Each video lecture included the same PowerPoint slides, and a female instructor taught the topic while standing next to the slides. In the no social cues condition, the instructor stood still (no hand movements or gaze shifts) and looked into the camera while teaching. In the directed gaze condition, the instructor did not move her hands, but she produced 15 gaze shifts to the relevant learning content on the slides. In the pointing gesture condition, the instructor produced 15 pointing gestures to the same relevant slide areas as in the directed gaze condition. In the directed gaze + pointing gesture condition, the instructor looked at and pointed to the same relevant slide areas 15 times. Fig. 1 provides an illustration of each video lecture condition.

#### 2.3.2. Measurements

##### 2.3.2.1. Prior knowledge test

This test was developed by the instructor in the video lecture, and it included three fill-in-the-blank

![Fig. 1. Snapshot of each video lecture condition.](image-url)
items and six multiple-choice items. The items assessed general knowledge of reproduction and cloning, and no item was about the specific learning topic in order to avoid any effects of expectation on learning performance (e.g., “Sexual reproduction means that after combine and formulate, it grows up into a new individual”; “The essential difference between sexual reproduction and asexual reproduction is: A. whether generative cells generate; B. whether there is only one parent; C. whether there is cell division; D. whether gender germ cells combine”). The three fill-in-the-blank items included eight blanks, and each correct answer was assigned 1 point. Each multiple-choice item had four answer choices but only one correct answer, and 2 points were given for each correctly answered item. Therefore, the total possible prior knowledge score was 20 points ($M = 9.49$, $SD = 2.53$). There was no significant difference on prior knowledge between the four conditions ($F(3, 116) = 0.56$, $MSE = 6.49$, $p = .64$, $\eta^2 = 0.01$).

2.3.2.2. Retention test. The retention test was developed by the instructor in the video lecture in order to test participants’ retention of key concepts. It included five fill-in-the-blank items (eight blanks total, e.g., “The reproduction of bacteria is, and the reproduction of saccharomycetes is.”) and one multiple-choice item. The scoring method was the same as in the prior knowledge test. Therefore, the total possible score was 10 points.

2.3.2.3. Transfer test. The transfer test was also developed by the instructor in the video lecture to test participants’ ability to use the knowledge from the lecture in novel situations. It included eight multiple-choice items (e.g., “What cannot generate spores? A. bacteria; B. saccharomycetes; C. mushroom; D. penicillium”) and another set of material analysis items. In the material analysis items, participants read two novel situations and answered three questions (one fill-in-the-blank question and two multiple-choice questions). The scoring method for the fill-in-the-blank question and the multiple-choice questions was the same as in the prior knowledge test. Therefore, the total possible score was 21 points.

2.4. Eye movement data analysis

To analyze the effects of the instructor’s pointing gestures and directed gazes on students’ efficiency of visual search and attention allocation, 15 areas of interest (AOIs) were created on the slides according to the areas to which the instructor referred. We used eye tracking to calculate (a) the average of first fixation times on the 15 AOIs and (b) the average percentage dwell time on the 15 AOIs.

2.5. Procedure

The study was carried out in a laboratory and took approximately 40 min. Firstly, all participants completed the prior knowledge test, and then they were escorted to an eye-tracking room. The participants were randomly assigned to one of the four conditions: the no social cues condition, the directed gaze condition, the pointing gesture condition, and the directed gaze + pointing gesture condition. Participants individually watched the video lecture without pause, and they completed the retention and transfer tests immediately after watching.

3. Results

Descriptive statistics for all variables are shown in Table 1. A series of four analyses of variance (ANOVAs) with the experimental condition (no social cues vs. directed gaze vs. pointing gesture vs. directed gaze + pointing gesture) as the between-subjects factor were conducted on the retention test score, the transfer test score, mean first fixation time on AOIs, and mean percentage dwell time on AOIs.

3.1. Effects of instructor’s directed gaze and pointing gestures on learning performance

To test our hypotheses that participants in the directed gaze + pointing gesture condition would show the highest learning performance, followed by participants in the pointing gesture condition, participants in the directed gaze condition, and finally participants in the no social cues condition (H1 and H2), we analyzed their performance on the retention and transfer tests.

Table 1
Means and standard deviations of all variables.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>No social cues</th>
<th>Directed gaze</th>
<th>Pointing gesture</th>
<th>Directed gaze + pointing gesture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Retention</td>
<td>5.37</td>
<td>1.77</td>
<td>5.93</td>
<td>1.68</td>
</tr>
<tr>
<td>Transfer</td>
<td>12.23</td>
<td>3.20</td>
<td>13.93</td>
<td>3.53</td>
</tr>
<tr>
<td>First fixation time on AOIs</td>
<td>706.43</td>
<td>368.94</td>
<td>468.53</td>
<td>297.62</td>
</tr>
<tr>
<td>Percentage dwell time on AOIs</td>
<td>0.61</td>
<td>0.09</td>
<td>0.64</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Note: The unit of first fixation time was millisecond.
3.1.1. Retention

There was a significant difference in retention test scores across the four conditions ($F (3, 116) = 3.27$, $MSE = 3.59$, $p = .024$, $\eta^2 = 0.08$). Further, post hoc tests revealed that participants in the pointing gesture condition and the directed gaze + pointing gesture condition showed significantly higher retention scores than those in the no social cues condition (see Fig. 2). No other significant differences were found ($ps > .05$).

3.1.2. Transfer

There was a significant difference in transfer test scores across the four conditions ($F (3, 116) = 2.94$, $MSE = 11.76$, $p = .036$, $\eta^2 = 0.07$). In addition, post hoc tests found that participants in the pointing gesture condition and the directed gaze + pointing gesture condition showed significantly higher transfer scores than those in the no social cues condition (see Fig. 3). No other significant differences were found ($ps > .05$).

In summary, these findings suggested that both the instructor’s use of pointing gestures and her combined use of pointing gestures and directed gaze in the video lecture improved participants’ learning performance compared to using no social cues. Surprisingly, there was no difference between her use of only pointing gestures and only directed gaze on participants’ learning performance. The above results partially supported our hypotheses.

3.2. Effects of instructor’s directed gaze and pointing gestures on attention

To examine to what extent participants’ attention was guided by the instructor’s directed gaze and pointing gestures, we compared mean first fixation time (H3) and mean percentage dwell time (H4) across the four conditions.

3.2.1. First fixation time

To test our hypothesis that the instructor’s directed gaze and pointing gestures would efficiently guide participants’ attention to the areas that she was talking about, we analyzed participants’ mean first fixation time on AOIs (H3). There was a significant difference between the four conditions ($F (3, 116) = 5.96$, $MSE = 81779.17$, $p = .001$, $\eta^2 = 0.13$). Post hoc tests further found that participants in the no social cues condition took a significantly longer time to fixate on the areas that the instructor was talking about...
than did those in the directed gaze condition, pointing gesture condition, and directed gaze + pointing gesture condition (see Fig. 4). No other significant differences were found ($p > .05$).

3.2.2. Percentage dwell time

To test our hypothesis that the instructor’s directed gaze and pointing gestures would promote attention to the areas that she was talking about, we analyzed the mean percentage dwell time on AOIs (H4). There was a significant difference across the four conditions ($F(3, 116) = 4.80$, $MSE = 0.01$, $p = .003$, $\eta^2 = 0.11$). Post hoc tests showed that participants in the pointing gesture condition and the directed gaze + pointing gesture condition paid greater attention to the relevant slide areas than those in the no social cues condition and the directed gaze condition (see Fig. 5). No other significant differences were found ($p > .05$).

In summary, these results suggested that both the instructor's pointing gestures and her pointing gestures combined with directed gaze not only efficiently guided participants to the relevant slide areas, but also guided them to allocate greater attention to those areas; by contrast, the instructor's directed gaze only improved participants' efficiency of visual search to the relevant slide areas. Furthermore, neither the instructor's pointing gestures nor her pointing gestures combined with directed gaze differed from her directed gaze alone in improving visual search; however, they were superior to her directed gaze alone in improving the amount of attention participants paid to the relevant slide areas. The results partially supported our hypothesis.

4. Discussion

The main aim of the present study was to compare the effects of two types of instructor behavior in video lectures, namely directed gaze and pointing gesture, on students' learning performance and attention. Students in the conditions that included the instructor's pointing gesture not only showed better learning performance, but also efficiently searched for and paid greater attention to the area of the slide that the instructor was referring to. The findings indicated that the instructor's pointing gesture always...
improved students' learning, regardless of her directed gaze used in video lectures. This is the first study to distinguish the effects of the instructor's pointing gestures from the effects of directed gaze on students' learning performance, efficiency of visual search, and attention allocation.

As expected, the instructor's pointing gestures improved students' retention and transfer; furthermore, her pointing gestures facilitated students' visual search and guided them to pay greater attention to the relevant areas of the slide. The results were consistent with previous studies and with CTML and CLT (Mayer, 2005; Pi et al., 2017; Rueckert et al., 2017; Sweller, 1988). CTML and CLT assume that the main function of an instructor's pointing gesture is guiding students' attention; that is, the gesture could help students efficiently search for the key information and meanwhile allocate greater attention to the information. As a consequence, students could use limited cognitive sources to construct the requisite mental model. We infer that the instructor's pointing gestures improved students' learning performance by guiding their attention.

Compared with students in the no social cues condition, students in directed gaze condition showed higher efficiency of visual search, but not greater attention allocation to relevant areas of the slides mentioned by the instructor or higher learning performance. These results are consistent with those of previous empirical studies (Ouwehand et al., 2015; van Wermeskerken & van Gog, 2017). Although the instructor's directed gaze guides students in an efficient search for relevant information (as does the pointing gesture), it might not be helpful with allocating information. That might be why students who viewed the video lectures that included the instructor's pointing gestures, but not those who viewed the video lecture with only directed gaze, showed significantly higher learning performance than those who viewed the video lectures with neither her pointing gestures nor directed gaze.

Furthermore, there might be benefits when the instructor always looks straight into the camera rather than shifting her gaze from the camera to the relevant information. Specifically, students might believe that she is looking at them, and they might try to make eye contact with her (Leong et al., 2017). Research has suggested that this kind of eye contact not only stimulates and reinforces listeners' social responses (e.g., smiling), but it also improves their learning by neural synchronization (Leong et al., 2017; Mayer, 2005). This might explain why the present study and previous empirical studies did not find that students viewing a video lecture with the instructor's directed gaze learned less than those viewing a video lecture without the directed gaze (i.e., video lectures in which the instructor was making eye contact; Ouwehand et al., 2015; van Wermeskerken & van Gog, 2017). Future work is needed to test the effect of an instructor's eye contact on students' learning by using a video lecture without her image for comparison, thus providing a way to distinguish the effects of the instructor's directed gaze from her eye contact.

The results of this study are significant because they add important information to the literature on instructors' pointing gestures and directed gaze in video lectures. To the best of our knowledge, this is the first study to distinguish the effects of the instructor's pointing gestures from the effects of her directed gaze on students' learning performance, visual search, and attention allocation during video lectures. Furthermore, although researchers have claimed that both pointing gestures and directed gaze could reduce students' extraneous visual search, they did not directly test independent and combined effects. In the present study, we directly tested whether an instructor's pointing gestures and directed gaze could efficiently guide students' attention to the relevant areas of the slide, as indicated by first fixation time. This eye movement indicator is believed to reflect the efficiency of visual search (Yan et al., 2013).

There are two limitations in the present study. Firstly, the topic of the video lecture was how creatures reproduce and clone, but the topic of previous studies on an instructor's directed gaze was a problem-solving task (e.g., how to build the molecule glutamine). Further research is needed to examine whether our findings can be generalized to other school subjects. Second, the current study did not consider the moderating role of students' level of prior knowledge. Research has shown that students with low prior knowledge might be more effectively guided by attentional cues (e.g., the instructor's pointing gestures) than students with high prior knowledge (Arslan-Ari, 2018; Kalyuga, 2014). Further research is needed to examine whether the effects of the instructor's pointing gestures and directed gaze are different for students with different levels of prior knowledge.

In conclusion, what stood out in the present study was that the instructor's pointing gestures improved students' learning performance, visual search, and attention allocation, whereas directed gaze only improved their efficiency of visual search. Our results suggest that an instructor's pointing gestures improved learning regardless of her use of directed gaze. The findings have practical implications for educational practices to improve students' performance: An instructor is encouraged to use pointing gestures in video lectures with or without directed gaze.

**Statements on ethics and conflict of interest**

Before we conducted this study, we reported it to the Ethics Committee of the School of Psychology at Central China Normal University and received permission from the committee to conduct the research. In our study, all participants were volunteers who provided written informed consent. Furthermore, they knew that they had the right to withdraw from the study at any time during the experiment. We used numbers to refer to the participants instead of their names. Their data were only used for the purpose of research.

There is no conflict of interest, as we conducted this study only because of our research interests.

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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.2018.10.006.

References