*Psychology Journal*, 2013
Vol. 10, No. 1
pp. 35-44

ISSN: 1931-5694
*www.psychologicalpublishing.com*


# Multimedia Learning from PowerPoint: Use of Adjunct Questions

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ABSTRACT - This study investigated the learning effects of inserting adjunct questions within a narrated PowerPoint science lesson about the anatomical and physiological processes involved in swallowing. Seventy-seven college undergraduate students were randomly assigned to one of two groups. In the experimental group, students wrote a response to eight open-ended adjunct questions that were inserted throughout the science lesson. The control group viewed the same lesson without the inserted questions. The experimental group performed significantly better than the control group on the retention/comprehension measure ($d$ = .37). However, the two groups did not differ in performance on the transfer measure. The finding supports the generative learning theory as a model for how learners retain information from presentation media and suggests that adjunct questions may be an effective way of encouraging retention/comprehension when learning from narrated presentation software. Limitations and suggestions for further investigation of the adjunct questioning effect were offered.

Presentation software such as Microsoft PowerPoint (2010) has become a standard in instructional settings (Gupta, 2011; Kraus, R. 2008; Schrad, 2010). In spite of its popularity, however, many have voiced concern regarding the pedagogical utility of presentation software. One criticism comes from those who suggest that the use of presentation software tends to decrease student engagement (Craig & Amernic, 2006; Klemm, 2007; Schrad, 2010). Craig and Amernic point out that the major pedagogical issue with PowerPoint presentations is that learners are passively rather than actively engaged in the process of learning. Klemm suggested that the visual presence of PowerPoint slides on a large, rectangular, illuminated screen is analogous to information delivered on movie or televisions screens. He suggested that this manner of presentation encourages a more passive "entertain me" (p, 122) learner mode. How might we encourage active learner engagement, and ultimately improve comprehension, when using presentation software?

Adjunct questions are "questions which have been added to instructional text to influence what is learned from the text" (Mory, Chen, & Saad, 1991, p. 4). Adjunct questions are known to encourage students to actively engage in the processing and comprehension of text (Hamaker, 1986; Hamilton, 1985) and more recent research has

shown that adjunct questions appear to enhance the retention of web-based materials as well (Dornisch & Sperling, 2004; Dornisch & Sperling, 2006). Inserting adjunct questions into a presentation software lesson may be one way to encourage active engagement, not only in classroom-based presentations, but in more physically distant online presentations as well. However, few studies have investigated the use of adjunct questions with presentation software.

## Theoretical Rationale for Use of Adjunct Questions

The use of adjunct questions to support learning is based on Wittrock's (1974) generative learning theory. Generative learning theory proposes that learners construct knowledge by building associations between prior knowledge and new material that is presented to them. The premise that learners construct, rather than receive, knowledge has been well articulated by more contemporary researchers (Bransford, Brown, & Cocking, 1999; Mayer, 2009).

Mayer's Cognitive Theory of Multimedia Learning (CTML, Mayer, 2005, 2009) specifically addresses how cognitive processes influence a change in one's knowledge when learning from multimedia sources. This model assumes that humans possess separate channels for processing visual and auditory information, that each channel is limited in the amount of information held at one time, and that humans actively process information by engaging in three processes: (a) selecting perceptual elements, (b) organizing coherent mental representations, and (c) integrating incoming material with existing knowledge.

Research on the use of adjunct questions to improve text comprehension (Hamaker, 1986; Hamilton, 1985; Rickards, 1976) suggests that inserted adjunct questions may encourage the mental review of previously read material (backward effects) and in turn guide the learner to selectively attend to material yet to be read (forward effects). What is less clear is how multimedia instruction in the form of narrated PowerPoint instruction, as opposed to instruction in the form of text, is influenced by adjunct questions. In light of Mayer's (2005, 2009) CTML, this investigation proposes that forward effects offered by adjunct questions may assist learners to select perceptual elements on subsequent PowerPoint slides. The backward effects may assist in the organization of the learning material of the PowerPoint slides recently viewed. Composing a response to the adjunct question may promote the integration of information contained in the lesson with learners' existing knowledge.

## Adjunct Questions with Presentation Software

Campbell and Mayer (2009) found large and significant differences, primarily on their retention measures, for students who were given the opportunity to respond to adjunct questions during a live lecture using presentation software. Gier and Kreiner (2009) also found large and significant learning effects, mainly on their retention measure, for groups using adjunct questions. However, the Gier and Kreiner study contained serious internal validity threats (e.g., comparison of intact groups from two different institutions) and while the Campbell and Mayer study utilized stronger experimental controls (i.e., random selection to conditions and evidence for group equivalency), their study showed conflicting findings. In their first experiment, the use of

adjunct questions facilitated retention, but had no effect on either the open-ended transfer test or on the multiple-choice measures. In their second experiment, the use of adjunct questions had no effect on the retention or multiple-choice measures, but did have an effect on the open-ended transfer measure. Clearly this line of research requires further investigation.

### Purpose

This study will investigate the effects of adjunct questions that are inserted into a narrated PowerPoint lesson. The adjunct questions are intended to improve the retention/comprehension and near transfer of concepts pertaining to a PowerPoint lesson on the process of swallowing. It is hypothesized that students who view the lesson with adjunct questions will retrieve, comprehend, and transfer the lesson material better than those who view the same lesson without adjunct questions.

## Method

### Participants

Participants included 77 students (13 male, 64 female) who ranged in age from 18 to 35 years (70 percent were 21 years or younger). Participants were undergraduate college students attending a southwestern university. Students were recruited from two undergraduate courses in communication disorders (not taught by the author). Students received course credit (5% of their grade) for their participation in the study. They were given full credit if they participated throughout the experiment regardless of their performance on the dependent measures. Course credit was in no way contingent upon their performance on any measure given throughout the experiment. Students were given the option to complete an alternate assignment (read and answer three open-ended questions about a journal article) to receive the same course credit.

### Materials and Procedure

**Apparatus.** The apparatus consisted of seven Pentium 4 desktop computers. Each computer was equipped with one set of Sony over-the-ear headphones (model number: MDRZX100/BLK). Participants were seated at one of seven study carrels where they viewed the narrated PowerPoint lesson on a 17-inch flat screen display.

**Lesson.** The narrated PowerPoint lesson was a computer-controlled web-based lesson that was developed using Producer for PowerPoint (2011). The lesson consisted of 16 narrated PowerPoint slides that defined relevant terminology, displayed pertinent anatomical structures, and described the four stages of swallowing. Each slide contained two to four bulleted texts and one static illustration. Some slides also contained simple animations (i.e., arrows pointing to pertinent aspects of illustrations). A brief (3-5 sentences) spoken narrative was synchronized with the appearance of bulleted text, animations, and static images.

**Measures.** Prior-knowledge was measured using a single question that asked the participants to "Describe what you know about swallowing". Participants were told to respond at their own rate. Responses were scored using a 12-item rubric. The rubric listed 12 general concepts pertaining to the process of swallowing (i.e., any mention of anatomical structures, swallowing processes, etc.). One point was awarded for any of the

12 concepts. Twelve points were possible on this measure but actual scores ranged from zero to 6 points. A random selection of 25 responses was rated by two independent raters. Interrater reliability was very good ($r$ = .95).

Retention/comprehension was measured by asking participants to recall and explain information from the lesson about swallowing. Participants were asked to, "Write down all you can recall (words, diagrams, images, etc.) about the lesson on dysphagia." Participants were given 10 minutes to complete this task. One point was awarded for the following: 1.) each defined term, 2.) each labeled drawing, 3.) each description of one of four stages of swallowing, 4.) each description of the location of an anatomical structure, 5.) each description of the function of an anatomical structure. This measure was designed to not only assess free-recall retention of the narrated PowerPoint lesson but also to assess how well the participants comprehended the information they recalled. Credit was given only when the response contained a pertinent term (i.e., oral preparatory, mastication, bolus, etc.) and illustrated, described or defined that term (i.e., mastication means to chew food). Scores ranged from zero to 18. A random selection of 25 participant responses was rated by two independent raters. Interrater reliability was good ($r$ = .84).

Transfer of learning involves the ability to "apply something learned to a new problem or situation" (Bransford & Schwartz, 1999). Two questions were constructed and posed to the participants to measure transfer. The first question was, "Given a patient who has difficulties in phase three (pharyngeal phase) of the swallowing process, predict and describe the anatomical/physiological indicators." The second question was, "Describe the consequences of severe tooth loss (i.e., less than 25% of teeth present) on all phases of the swallowing process." Participants were given 10 minutes to write their response to each question. Responses for both questions received one point for each plausible response to the question posed. For example, a plausible answer for the first question might be, "Difficulty in the pharyngeal phase of swallowing might result in aspiration of food or liquid in the trachea." A plausible response for question two might be, "Severe tooth loss might result in the loss of appetite or the desire to eat." Participants responded with 14 different plausible responses to question one and ten different plausible responses to question two. Participant scores ranged from one to six for both questions and mean scores did not significantly differ across the two questions, $t$ (76) = -.58, $p$ = .56. Therefore the two transfer test scores were aggregated to arrive at a total transfer estimate. A random selection of 25 participant responses was rated by two independent raters. Interrater reliability was good on both transfer questions one and two ($r$ = .80 and .84 respectfully).

**Participant Note-taking**

All participants were instructed to take notes while viewing the narrated PowerPoint presentation. Although students were randomly assigned to conditions, it is conceivable that the amount of participant note-taking may have differed significantly across the *adjunct-question* (AQ) and the *non-adjunct-question* (NAQ) groups. Given that note-taking has been shown to facilitate retention of the lecture material (Boyle, 2011; Kiewra, 1989), student notes were analyzed and scored in terms of content. That is, the students' notes were scored so that each pertinent concept (i.e., term, definition, or explanation)

received one point if it specifically pertained to the narrated PowerPoint on the process of swallowing. Students' notes that consisted of misconceptions (i.e., "food travels down the trachea") or vague/ambiguous statements (i.e., "chemical allowing it to go down, or "cranial nerve 12 – after bolus") received zero points. Interrater reliability was determined by collecting a random selection of 25 participant responses rated by two independent raters. Interrater reliability was good ($r$ = .89).

**Procedure**

After obtaining informed consent, students were randomly assigned to either the Adjunct question (AQ) or the No adjunct question (NAQ) group and were seated at a computer work-station. Students first wrote their response to the prior-knowledge open-ended question. Second, students completed a demographic questionnaire. Finally, students viewed a narrated PowerPoint lesson on the processes of swallowing. Participants in the AQ condition were instructed to write their answer to the adjunct questions on an 8 ½ by 11 inch note pad. To control for possible participant bias (e.g., compensatory rivalry, see Cook & Campbell, 1979), participants in both conditions (AQ and NAQ) were given a pencil and an 8½ by 11 inch note pad and were instructed to take notes throughout the lesson.

For the AQ condition, participants viewed a narrated PowerPoint lesson that contained eight related open-ended (four factual and four higher-order) adjunct question slides inserted into the lesson. One question followed every two lesson slides. The adjunct questions pertained to the information that was contained on the previous two lesson slides. The adjunct question slide asked participants to write the question number along with their response to the question. Participants were given 30 seconds to respond.

For the NAQ condition, participants viewed the same narrated PowerPoint lesson. However, instead of viewing an adjunct question slide, participants viewed a "sit-and-wait" slide that contained the following text, "Stop – The Lesson Will Continue in Thirty Seconds. DO NOT touch any controls" with the accompanying narration, "The lesson is streaming information for the next few slides. Please wait for 30 seconds. Do not touch any controls." The "sit-and-wait" slide was shown after every two lesson slides.

Following the lesson, participants were given 10 minutes to respond to the free-recall retention/comprehension measure. After the free-recall retention/comprehension measure was collected, participants were given 10 minutes to answer each of two transfer questions. For each question, participants were told that they had 10 minutes to respond and were reminded to continue working until the time was up. Finally participants were debriefed and given credit for their participation.

## Results

**Descriptive Analysis**

Descriptive data were analyzed to determine sample-specific relationships and to evaluate whether the data met statistical assumptions. Statistical assumptions for all planned analyses were met and alpha was set at .05 to evaluate type I error on all analyses.

Table 1 shows the means and standard deviations for the two conditions (AQ & NAQ) on the note-taking measure, the prior-knowledge measure, the

retention/comprehension measure, and the transfer measure. As shown by Table 1, there was little difference between conditions (AQ minus NAQ) on the prior-knowledge and transfer measures (*M* difference = .61, -.55 respectively) but larger mean differences between conditions was shown on the recall/comprehension and note-taking measures (*M* difference = 1.67)

**Table 1**
***Means and Standard Deviations for Conditions (Adjunct & No Adjunct Questions) across Prior-Knowledge, Note-Taking, Retention/Comprehension and Total Transfer Measures***

| | **Adjunct Question (AQ N = 39)** | **No Adjunct Question (NAQ N = 38)** |
|---|---|---|
| **Prior-Knowledge** | 1.76 (1.78) | 1.15 (1.27) |
| **Note-Taking** | 27.03 (12.70) | 34.46 (13.34) |
| **Retention/Comprehension** | 7.39 (5.53) | 5.72 (3.53) |
| **Transfer** | 2.68 (1.88) | 3.23 (2.44) |

**Group Equivalency**

Four analyses, each a one-way analysis of variance (ANOVA), were conducted to determine if the two groups (AQ & NAQ) differed significantly from one another in terms of age, sex, note-taking, or prior knowledge. The conditions AQ and NAQ did not differ significantly on the prior knowledge measure or on the variables age and sex, suggesting group equivalency between the conditions on the three measures. However, the NAQ condition scored significantly higher than the AQ condition on the note-taking measure, $F$ (75, 1) = 6.02, $p$ = .02, $\eta^2_{partial}$ = .07, and a small but significant relationship was shown between the note-taking measure and the retention/comprehension test, $r$ (76) = .25, $p$ = .03. Given that the note-taking variable could potentially influence the causal

relationship shown between the experimental conditions (AQ and NAQ) and the dependent measures (i.e., retention/comprehension and transfer tests), the variable note-taking was added as a covariate to control for variation of student note-taking on the dependent measures.

**Adjunct Question Effects on the Retention/comprehension and Transfer Measures**

As Table 1 shows, participants given adjunct questions (AQ group) scored significantly higher on the retention test than those who were given 30 second wait periods instead of adjunct questions (NAQ group). A one-way analysis of covariance (ANCOVA) with group (AQ & NAQ) as the independent variable, note-taking as the covariate, and the retention/comprehension test as the dependent measure revealed a significant effect for group, $F$ (1,74) = 5.58, $p$ = .021, $d$ = .37. However, the one-way ANCOVAs on the transfer measure revealed that the groups did not significantly differ, $F$ (1, 74) = .15, $p$ = .70, power (alpha = .05) = .07.

## Discussion

Presentation software, such as Microsoft PowerPoint (2010), is widely used in post-secondary settings. Many have voiced opinions both in support of and against the use of such software in educational settings (Craig & Amernic, 2006; Klemm, 2007; Kraus, 2008; Parker, 2001; Tufte, 2003). Rather than offer expert opinion concerning the pedagogical strengths and weaknesses of presentation software, this study chose to investigate whether the instructional effectiveness of such software may be improved by adding a feature (i.e., adjunct questions) that has been previously shown to encourage active learner engagement in text-based lessons.

Reviews by Hamilton (1985) and Hamaker (1986) have shown that the use of adjunct questions appears to support active engagement in text comprehension. However, there is less support for the use of adjunct questions when using multi-media approaches such as presentation software. This study compared the outcomes on two learning measures of students who answered adjunct questions inserted within a narrated PowerPoint presentation (adjunct question group) with those who saw the same narrated PowerPoint presentation with no adjunct questions (control group). The group receiving adjunct questions significantly outperformed the control group on an open-ended retention/comprehension measure. However, group performance did not differ significantly on the transfer measures.

Like the Campbell and Mayer (2009) study, this investigation went beyond observational studies to investigate the effect of questioning on cognitive learning measures. Unlike the Campbell and Mayer study, this investigation utilized open-ended, rather than a multiple-choice adjunct question format and this study did not offer corrective feedback with the adjunct questions. In addition, the lesson used in this study was uniformly presented using a computer-controlled narrated PowerPoint presentation (rather than Campbell and Mayer's live instructor presentation).

Nonetheless, the findings from this study were similar to those in the Campbell and Mayer (2009, experiment one) study, in which the use of adjunct questions improved retention of the lesson material but had little effect on transfer. This study adds support to the empirical evidence pertaining to the use of adjunct questions for improving

learning/retention in lessons that use presentation software. However, further investigation is needed to determine how the use of adjunct questions, inserted in presentation software, might encourage transfer of knowledge.

**Theoretical implications and future directions**

How do students benefit from the use of adjunct questions inserted within a narrated PowerPoint presentation? The adjunct questions used in this study were inserted after the relevant lesson material (i.e., postquestions) and they focused on material that was actually contained in the lesson (repeated questions). The literature pertaining to text comprehension (Hamaker, 1986; Hamilton, 1985) suggests that postquestions encourage the learner to mentally review the previously read material (backward effects) and to be more attentive to the material yet to be read (forward effects). This study examined how these same backward and forward effects might apply to learning from multimedia (i.e., narration, images, animations, and text) instruction. That is, backward effects of the adjunct postquestions should enable learners to build stronger and more coherent mental representations of the lesson material. Forward effects of the adjunct questions should prepare learners to be more attentive to the PowerPoint material to be presented next and thereby enable learners to more easily select pertinent lesson elements.

Relating theses effects to Mayer's (2005, 2009) CTML, the use of adjunct postquestions in a narrated PowerPoint lesson should support learning in the following ways: First, adjunct questions should enable better *selection* of pertinent terms and concepts contained within the lesson through forward effects. Second, adjunct questions should support the representation of the terms and concepts presented in the lesson with corresponding and coherent images, explanations, or definitions through backward effects. Third, the act of composing a written response to the adjunct questions should enable pertinent connections among the concepts presented in the lesson with the learner's own prior knowledge in order to generate unique knowledge structures (i.e., transfer).

Unfortunately, the use of adjunct questions did not appear to support performance on the transfer measure. One possible explanation for this finding was that the participants may not have had sufficient time to prepare an answer to the higher-level adjunct questions. Sagerman and Mayer (1987) showed forward transfer effects on text comprehension when using higher-level adjunct questions. However, Sagerman and Mayer gave participants 90 seconds (rather than 30 seconds) to respond to higher-level adjunct questions. Future research should consider offering more time for participants to answer adjunct questions.

One unexpected result in this investigation was that students who were given adjunct questions (AQ group) noted significantly fewer concepts while taking notes than those in the control group (*Ms* 27.18 and 34.50 respectively). Taking careful notes would surely have improved students' performance on the adjunct questions, particularly since the adjunct questions were directly relevant to the information given prior to the question. Perhaps the task of answering the adjunct questions was viewed by the participants as a note-taking activity, given that the adjunct question repeated information offered in the prior two lesson slides. Another explanation is that the cognitive effort allocated to answering the adjunct questions reduced the available cognitive resources required to

take notes. Future research should consider how learner effort and cognitive load influence the learning effects of adjunct questions in multimedia presentations.

**Limitations**

This investigation took place in a laboratory rather than a classroom setting. It is limited in terms of participant selection (undergraduate college students seeking course credit) and in terms of lesson topic (normal swallowing). While the insertion of adjunct questions in a narrated PowerPoint lesson appears to support greater retention/comprehension of the lesson material, this instructional approach also appeared to significantly decrease the quantity of notes taken by students.

While not all areas of learning were improved by the use of adjunct questions, this study responded to questions concerning the *pedagogical benefit of presentation software*. More research is needed to investigate other variables that might support or inhibit learning when using adjunct questions with presentation software.

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