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The Effects of Segmentation and Personalization on Superficial and Comprehensive Strategy Instruction in Multimedia Learning Environments

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Short, cause-and-effect instructional multimedia tutorials that provide learner control of instructional pace (segmentation) and verbal representations of content in a conversational tone (personalization) have been demonstrated to benefit problem solving transfer. How might a more comprehensive multimedia instructional environment focused on strategy development influence the robustness of the segmentation and personalization principles? Students (n = 365) were randomly assigned to a control, segmented, or personalized multimedia group and engaged in either a superficial (3 min) or comprehensive (2.5 hr) multimedia strategy instruction tutorial. Students in the comprehensive-segmentation group outperformed all other groups on recall and application measures, and there were no personalization effects. The central application of the current research is that students will learn more deeply from longer and more complex multimedia tutorials that provide control over instructional pacing (segmentation).

Keywords: multimedia learning, segmentation, personalization, strategy instruction

INTRODUCTION

Instructional multimedia tutorials that provide learner control of the pace of instruction (segmentation) and where the verbal representations of content are in a conversational tone (personalization) have been demonstrated to benefit learner problem solving transfer (Mayer & Chandler, 2001; Moreno & Mayer, 2004). That is, when learners are able to control the flow of

information within a multimedia tutorial by determining when the next tutorial segment begins, learners tend to process the information more deeply as evidenced by increased in problem solving transfer (Mayer & Chandler, 2001; Mayer, Dow, & Mayer, 2003). In addition, when learners listen to or read verbal information that is spoken or written in a more conversational tone, rather than a formal tone, learners tend to process the information more deeply as evidenced by increases in problem solving transfer (Moreno & Mayer, 2000, 2004).

These principles of segmentation and personalization, however, have been determined using short multimedia tutorials or constrained simulations that focus on cause-and-effect or descriptive content (Mayer, Dow, & Mayer, 2003; Moreno & Mayer, 2000). How might a multimedia instructional environment that is more comprehensive and focused on strategy development influence the robustness of the segmentation and personalization principles? That is, can the generalization of the segmentation and personalization principles be ascertained within an instructional environment that focuses on a more comprehensive approach, rather than a superficial approach, and within a strategy domain, rather than a cause-and-effect or descriptive domain?

The segmentation principle and learner control

The segmentation principle states that individuals will learn more from multimedia tutorials that provide the ability to control the pace of the tutorial, rather a tutorial that simply plays from beginning to end (Mayer & Chandler, 2001). The operationalization of the segmentation principle includes (a) dividing a multimedia tutorial into sections, or segments; (b) having each segment play and then stop at the end of the segment; and (c) providing a "Continue" button to allow the learner to advance to and play the next segment. The segmentation principle is based on the premise that engaging in a tutorial from beginning to end, without stopping, may result in cognitive overload within the learner if the tutorial contains significant amounts of information and informational interaction (Mayer, 2005a). This cognitive overload would then degrade learning. Providing segmentation, however, would allow the learner to stop at the end of each segment and process the information within the segment sufficiently before proceeding to the next segment.

Mayer and Chandler (2001) created two version of a multimedia tutorial addressing the cause of lightning, segmented (S) and non-segmented (NS). Participants either engaged in the S version first, followed by the NS version, or vice-versa (Exp 1). Mayer and Chandler found that the S-NS group performed better on a transfer task, but not on a recall task, than the NS-S group. Mayer and Chandler attributed the superior transfer performance of the S-NS group to participants avoiding cognitive overload and being able to build models of the component parts of the lightning cause-and-effect relationship during this first engagement (S). During the second engagement (NS), the participants were then able to connect and organize the component parts. Mayer and Chandler (Exp 2) then had additional participants engage in either the S version twice or the NS version twice. In this case, Mayer and Chandler found that participants in the S-S group performed better than the NS-NS group on the measure of transfer, but not on the measure of recall. In addition, Mayer et al. (2003 [Exp 2a and 2b]) assessed the segmentation principle by provided the participants with segment control over a multimedia tutorial addressing the working of an electric motor. Mayer et al found that participants who engaged in a segmented multimedia tutorial performed better on a transfer task than participants who engaged in a non-segmented multimedia tutorial.

While Mayer and Chandler (2001) and Mayer et al. (2003) found segmentation control, or learner control, beneficial, such results are not always typical. There is an extensive body of empirical literature on learner control in instructional environments, especially in computer-based instruction (CBI), that has demonstrated conflicting results for the effects of learner control on achievement (see Niemiec, Sikorski, & Walberg, 1996; Steinberg, 1989; Williams, 1996). Learner control within this literature base includes control over the inclusion of content, depth of content, order of content, pacing, practice, and/or feedback (Kinzie, Sullivan, Berdel, 1988; Milheim, 1990; Pollock & Sullivan, 1990; Pridemore & Klein, 1993). Within this broad base of literature, there are studies that support learner control (see Shyu & Brown, 1992), studies that do not support learner control (see Pollock & Sullivan, 1990), and studies that are neutral on learner control (Klein & Keller, 1990); however, most studies have found no differences between learner control and program control (Williams, 1996). When examining the literature specifically on learner control of pacing, what Mayer and Chandler (2001) term segmentation, the results also tend to be conflicting (Aly, Elen, & Willems, 2005; Dalton, 1990; Milheim, 1990).

These conflicting findings regarding learner control of pacing control, or segmentation, are evident in Mayer and Chandler (2001) who found a significant difference in transfer, but not in recall, between learner controlled/segmented multimedia tutorials and non-learner controlled/non-segmented multimedia tutorials. Mayer et al. (2003) did not even measure recall in Experiments 2a and 2b. In addition, Mayer and Chandler (2001) indicate that further research was needed to explore the questions of whether or not there may be differences in the segmentation principle between (a) short duration multimedia tutorials, such as a 2.3 minute tutorial (Mayer & Chandler,

2001), and long duration multimedia tutorials, such as a 2.5 hour tutorial over four days (the present study); and (b) cause and effect multimedia tutorials, such as a "what causes lightning" tutorial (Mayer & Chandler, 2001), and strategy tutorials, such as a "how to engage in historical inquiry" tutorial (the present study).

The personalization principle and social cues

The personalization principle states that individuals will learn more from multimedia tutorials when the verbal representations, narration or on-screen text are in a conversational tone, rather than a formal tone (Mayer, 2005b). The personalization principle is based on the premise that personalized verbal representations, spoken or written, using first- and second-person grammatical constructions, activates a social response in the learner. This social response involves the learner engaging with the computer-based multimedia tutorial as a social partner. The premise continues that this social response will then lead to an increase in active cognitive processing. This increase in active cognitive processing results from the learner desiring and committing to understand the multimedia instruction.

Within multimedia instruction, the personalization principle is based on two attributes: first- and second-person grammatical constructions and the addition of personally engaging prose. Specifically, Moreno and Mayer (2000) had participants engage in a short multimedia tutorial addressing the cause of lightning in one of two conditions. In the personalized condition the narration (Exp 1) or on-screen text (Exp 2) used first- and second-person grammatical constructions with additional personally engaging prose, while the neutral condition used third person constructions with no additional prose. Measures of recall indicated no significant differences between the multimedia tutorials using personalized and neutral verbal representations; however, there were significant differences in measures of transfer. This pattern of non-significant recall findings and significant transfer findings, based on personalization, was also apparent in three experiments involving learners engaging in a short multimedia tutorial addressing how the human respiratory system works (Mayer, Fennell, Farmer, and Campbell, 2004). Moreno and Mayer (2000 [Exps 3-5], 2004) did, however, find both a recall effect and a transfer effect for personalization when learners engaged in a multimedia biological plant-construction simulation.

These findings provide evidence of a personalization effect; that is, that learners learn more from multimedia tutorials that incorporate personalized verbal representations rather than neutral verbal representations. Moreno and Mayer (2000, 2004) theorized that personalization resulted from increases in self-referencing, interest, and social presence, and a decrease in

cognitive load, and that these changes led to a deeper level of processing; however, no direct evidence of changes in these constructs was demonstrated. Finally, Moreno and Mayer (2004) suggested that additional research is needed to assess the generalizability of personalization, including its application across differing content areas (e.g., cause-and-effect versus strategy instruction) and levels of engagement or immersion (e.g., short and superficial versus long and comprehensive tutorials).

In accordance with the recommendations of Moreno and Mayer (2004), the present study was designed to assess whether personalization is evident when the content is historical, rather than biological or meteorological; the task is strategic, rather than cause-and-effect; and the level of engagement varies from superficial to comprehensive. Ultimately, the purpose of this study was to evaluate the segmentation and personalization principles across superficial and comprehensive strategy instruction. Specifically, the study was designed to (a) assess the segmentation principle using strategy instruction, (b) assess the personalization principle using strategy instruction, (c) assess the effects of superficial and comprehensive strategy instruction in a multimedia instructional environment, and (d) assess the interaction effects of superficial and comprehensive strategy instructional on the segmentation and personalization principles.

METHODS

Participants and design

The participants were 365 undergraduate students (196 men and 169 women) with a mean age of 20.3 years (SD = 1.82). Participants were enrolled in a non-majors health education course at a large research university in the southeast United States and received course credit for participation. The experimental design was a 2 X 3 factorial design with strategy instruction group (superficial, comprehensive) and multimedia group (control, segmented, personalized) as between-subject variables. Participants were randomly assigned to either the superficial (n = 163) or comprehensive (n = 202) strategy instruction group and one of the multimedia groups, control (n = 147), segmented (122), or personalized (96).

The SCIM historical inquiry multimedia tutorial

The SCIM historical inquiry multimedia tutorial was designed to scaffold students' understanding and application of the SCIM strategy for historical inquiry (see Hicks & Doolittle, 2007; Hicks, Doolittle, & Ewing, 2004). Historical inquiry is defined as a means for understanding the past by posing *historical questions*, gathering and analyzing *historical sources* in order

to create *historical evidence*, and constructing an *historical interpretation* based on the historical evidence and historical questions. The SCIM strategy itself is focused on four broad phases: summarizing, contextualizing, inferring, and monitoring. *Summarizing* involves quickly examining an historical source (e.g., letter, picture, object) in order extract any information or evidence that is readily available. *Contextualizing* involves locating the source in historical time and space and not succumbing to an interpretation of the source based on today's language, culture, or perspectives. *Inferring* involves moving beyond the source itself and drawing conclusions from the source based on what is implied or hinted at in the source. *Monitoring* involves examining one's questions and concerns by recursively reflecting upon initial and developing understandings during the course of summarizing, contextualizing, and inferring.

The SCIM historical inquiry multimedia tutorial was created in both a superficial and comprehensive strategy instruction version. The *comprehensive strategy instruction version* of the SCIM multimedia tutorial was approximately 2.5 hours in length over four days, involved narrated animation, was created using Adobe's Flash™, and conformed to the existing guidelines for strategy instruction (see Pressley & Harris, 1990; Pressley & Woloshyn, 1995; Weinstein & Mayer, 1986). The SCIM tutorial was designed around three sections: strategy explanation, strategy demonstration, and strategy participation. The *strategy explanation* section was designed as a direct, step-by-step explanation of the SCIM strategy; the *strategy demonstration* section provided modeling of the SCIM strategy by an expert historian; and the *strategy participation* section provided the user with extensive practice in analyzing a primary source, with explicit feedback.

The strategy explanation section of the comprehensive strategy instruction version of the SCIM tutorial began with a short contextualization of the SCIM strategy within the larger picture of historical inquiry (i.e., historical questions, historical sources, historical evidence, and historical interpretations). The subsequent explanation of the SCIM strategy itself was based on an analysis of a letter from U.S. President Kennedy to Vice President Johnson, written in 1961, concerning the "space race" with the Soviet Union. The strategy explanation section moved step-by-step through the four phases of the SCIM strategy, explaining each step and demonstrating each step using President Kennedy's letter. Relevant information within the letter was either highlighted or extracted (see Figure 1), and the relevance of this information was then discussed in reference to the guiding historical question (*What was the significance of the Space Race during the 1960s?*). The explanation section ended by reflecting on the evidence and understandings gained, with special attention paid to questions and concerns that remained unresolved.

In the second section of the comprehensive strategy instruction version of the SCIM tutorial, the strategy demonstration section, learners were provided with the opportunity to observe an historian analyzing a letter written during the Depression by a 15 year-old-boy seeking financial assistance for school. A key to the strategy demonstration section was that it was built upon official transcripts of an expert historian analyzing the primary source letter. Procedurally, the strategy demonstration section involved a narrator cycling through the four phases of the SCIM strategy explicitly using each phase's analyzing questions to guide the analysis. During this narration, relevant analyzing questions and evidence from the letter were highlighted and extracted. An important aspect of this narration, highlighting, and extracting was that the process involved three foci – an analysis of a child's letter in 1939, the processes involved in implementing the SCIM strategy, and the thought processes of the historian relative to analyzing the letter using the SCIM strategy.

The third section of the comprehensive strategy instruction version of the SCIM tutorial involved extensive learner practice in analyzing primary sources with explicit feedback based on the learner's responses. During this section the learner was provided with an historical letter to read and analyze, and then a series of identification and interpretation questions. The first type of question, *identification*, focused on identifying explicit summary statements, one-dimensional contextualizing statements, obvious inferential statements, and superficial monitoring questions. The second type of question, *interpretation*, provided in-depth interpretive statements from which the user must determine the *best* answer through analyzing the source, synthesizing the information, and evaluating the evidence. After learners answered a given question they were provided with feedback that included knowledge of results (i.e., correct or incorrect), identification of key passages within the question, and aspects of the relevant SCIM phase upon which to pay special attention. Learners were asked to read and respond to these questions as they progress through the four phases of the SCIM strategy.

The *superficial strategy instruction version* of the SCIM multimedia tutorial was approximately 3 minutes in length, involved narrated animation, was created using Adobe's Flash™, and was comprised of two main sections. The first section discussed the general historical inquiry cycle including the asking of *historical questions*, the gathering of *historical sources*, the analyzing of historical sources to yield *historical evidence*, and the creating of *historical interpretations* addressing the original historical questions. The second section described the SCIM strategy for historical inquiry: *summarizing* the apparent and observable evidence, then *contextualizing* the source within the time and place in which the source was created, then *inferring* from the source conclusions that lie beyond the source, and finally, *moni-*

toring one's own thoughts for outstanding questions, needs for additional information beyond the source, and relevance of the source to the guiding historical questions.

Recall test and scoring

Participants' recall of the SCIM strategy was assessed using a single open-ended question: "Please provide an explanation of historical inquiry and the SCIM strategy." Participants completed this question by typing their responses into a text box on the computer screen. Two trained scorers evaluated each response (inter-rater reliability, r = .90) such that a response received one point for addressing each of the four stages of the general historical inquiry cycle (i.e., historical questions, historical sources, historical evidence, and historical interpretations) and two points for defining each of the four SCIM phases (i.e., summarizing, contextualizing, inferring, and monitoring). Thus, the maximum score for each recall test was 12.

Strategy application test and scoring

To assess participants' ability to apply the SCIM strategy, participants read an historical letter and then wrote an historical interpretation in a text box provided on the computer screen under the letter. The letter to be interpreted addressed farming in early 20th century in the mid-west United States and participants were instructed: "Use the letter below to help you in answering the following question: What does this source reveal about the conditions of life in farming communities on the great plains during the early 20th century?" Two scorers were trained to evaluate responses based upon the application of a scoring rubric. Each response was scored such that four points were possible for each of the four SCIM phases, for a maximum score of 16 points (inter-rater reliability, r = .84). Within the summarizing phase, participants received one point each for including the letter's subject, author, audience, and specific details. In addition, within the contextualizing phase, participants received one point each for including in the response when, where, and why the letter was written, as well as what was happening within the immediate and/or broader context in which the letter was written. While evaluating the inferring phase, participants received two points each for including in the response explicit and/or implicit inferences and inferences based on omissions within the letter. Finally, while evaluating the monitoring phase, participants received two points each for including in the response specific needs for additional information beyond the letter itself and the usefulness of the source in answering the historical question.

Treatment conditions.

Participants in the superficial and comprehensive strategy instruction groups were randomly assigned to one of three multimedia conditions: control, segmented, and personalized. The content of the superficial and comprehensive strategy instruction tutorials for each multimedia condition was the same, except for the following modifications. The superficial and comprehensive strategy instruction tutorials of the *control group* were created so that the tutorial played from beginning to end, without stopping (non-segmented), and used third-person grammatical constructions without including any comments designed to personally engage the learner (non-personalized). The superficial and comprehensive strategy instruction tutorials of the *segmented group* were the same as the control group tutorials except the short tutorials were divided into 15-20 second segments and the long tutorials were divided into 30-60 second segments. At the end of each segment, a "Continue" button would appear on the screen that when clicked, would allow the tutorial to proceed. This segmenting provided the learner with control over the pacing of the tutorials. The superficial and comprehensive strategy instruction tutorials of the *personalized group* were the same as the control group tutorials except the grammatical construction of the prose was changed from third person to first and second person (e.g., "these" to "your") and sentences were added to the tutorials that did not add content but were designed to personally engage the learner. The following provides an example of a non-personalized and a personalized segment from the superficial strategy instruction tutorial.

Non-Personalized

Historical inquiry is a cyclical process that begins with the asking of historical questions. These historical questions are investigated by locating, analyzing, and evaluating relevant historical sources. This analysis and evaluation of sources results in the creation of historical evidence. This historical evidence is then used to construct one possible historical interpretation relative to the historical questions.

Personalized

Imagine that you are reading a letter written by your great grandfather. What might the letter tell you about his life and the times in which he lived? Historical inquiry is a cyclical process that begins with the asking of those types of historical questions. Your historical questions are investigated by locating, analyzing, and evaluating relevant historical sources, such as your great grandfather's letter. An analysis and evaluation of your letter will result in the creation of historical evidence. This historical evidence, from

your letter, is then used to construct one possible historical interpretation relative to your historical questions.

These changes were designed to alter the style of the prose from formal to conversational, to foster interest in the content, and to elicit or encourage a social response.

Procedure

All data collection and media presentations were completed on wireless laptop computers. Participants in the superficial and comprehensive strategy instruction groups were studied separately. Those participants in the superficial strategy instruction group were required only to attend one experimental session. These participants, upon entering the computer lab and being assigned to a laptop computer and completed a demographics questionnaire. Participants were then provided brief instructions regarding the superficial version of the SCIM historical inquiry tutorial. Participants then engage in their specific version (i.e., control, segmented, or personalized) of the tutorial. Following the engagement in the tutorial, participants were given 10 minutes to complete the strategy recall test and 20 minutes to complete the strategy application test.

Those participants in the comprehensive strategy instruction group were required to attend four experimental sessions on different days during a single week. On the first day, upon entering the computer lab and being assigned to a laptop computer, participants completed a demographics questionnaire. Participants were then provided brief instructions regarding the comprehensive version of the SCIM historical inquiry tutorial. Students then engaged in the first 40-minute segment of their specific version (i.e., control, segmented, or personalized) of the tutorial. On the second and third days of the study, participants were again given brief instructions and then completed the second and third 40-minute segments of their specific version of the tutorial, respectively. On the fourth day, participants were again given brief instructions and then completed the final 40-minute segment of their specific version of the tutorial. Following engagement in the final tutorial segment, participants were given 10 minutes to complete the strategy recall test and 20 minutes to complete the strategy application test.

RESULTS

The purpose of this study was to evaluate the segmentation and personalization principles across superficial and comprehensive strategy instruction. Specifically, the study was designed to (a) assess the segmentation principle using strategy instruction, (b) assess the personalization principle using strategy instruction, (c) assess the effects of superficial and comprehensive strategy instruction in a multimedia instructional environment, and (d) assess the interaction effects of superficial and comprehensive strategy instructional on the segmentation and personalization principles. These questions were analyzed using two 2 (superficial, comprehensive) X 3 (control, segmentation, personalization) ANOVAs using the recall and application data. All post-hoc comparisons involved Tukey analyses with an alpha criterion of 0.05 and all effect size calculations involved Cohen's *d* (Cohen, 1998). Cohen's *d* effect sizes are interpreted as small, $d = 0.02$, medium, $d = 0.05$, and large, $d = 0.08$.

Superficial versus comprehensive strategy instruction

According to the cognitive strategy instruction literature (see Pressley & Harris, 1990; Pressley & Woloshyn, 1995; Weinstein & Mayer, 1986), participants that engaged in comprehensive strategy instruction involving explicit explanations, expert modeling, extensive examples, and practice with feedback should learn to understand and apply the strategy more readily than participants that engaged in superficial strategy instruction that included general explanations only. This superficial versus comprehensive strategy instruction effect was not confirmed for recall of the strategy (see Table 1), $F(1,359) = .003$, $MSE = 3.93$, $d = 0.02$, $p = .95$; however, the superficial versus comprehensive strategy instruction effect was confirmed for application of the strategy, $F(1,359) = 125.97$, $MSE = 6.11$, $d = 1.83$, $p = .00$. These results only partially confirmed the superficial versus comprehensive strategy instruction effect. That is, the present results indicate that comprehensive strategy instruction led to significant increases in the ability to apply the strategy, but not in the ability to recall the strategy.

Table 1.
Means and standard deviations of strategy recall and application scores for strategy instruction groups (superficial, comprehensive) and multimedia groups (Control, Segmented, Personalized).

	Strategy Instruction							
	Superficial				Comprehensive			
	Recall		Application		Recall		Application	
	M	SD	M	SD	M	SD	M	SD
Control	5.79	1.74	6.33	1.44	5.27	1.80	9.01	2.97
Segmented	5.89	2.21	6.55	1.73	6.67	2.04	10.53	2.80
Personalized	5.80	2.21	6.63	2.31	5.51	1.94	8.87	2.81
	5.83	2.04	6.49	1.83	5.78	2.01	9.48	2.96

Note: Maximum score for recall was 12. Maximum score for application was 16.

Segmenting and personalization principles

According to the cognitive theory of multimedia (see Mayer, 2001, 2005a), participants that engaged in a multimedia tutorial that provided control over viewing the tutorial in short segments (segmenting) should learn more than participants who engaged in a multimedia tutorial that did not provide segmented viewing control. In addition, participants that engaged in a multimedia tutorial that provided narration in a conversational tone should learn more than participants who engaged in a multimedia tutorial where narration was in a formal tone (personalization). These segmentation and personalization principles were assessed by comparing participants' strategy recall and application performance in conditions of segmentation and personalization with a control condition in which the multimedia tutorial was neither segmented nor personalized. Results of this analysis indicated a significant main effect for recall (see Table 1), $F(2,359) = 5.08$, $MSE = 3.93$, $p = .00$. A subsequent Tukey post-hoc analysis indicated that participants in the segmented group ($M = 6.31$, $SD = 2.15$) recalled significantly more strategy details than the control group ($M = 5.48$, $SD = 1.79$, $d = 0.41$). There was no significant difference in recall between the control group and the personalization group ($M = 5.66$, $SD = 2.08$, $d = 0.09$). The analysis of the strategy application data also demonstrated a significant main effect, $F(1,359) = 4.54$, $MSE = 6.11$, $p = .01$. A subsequent Tukey post-hoc analysis indicated that participants in the segmented group ($M = 8.70$, $SD = 3.09$) applied significantly more strategy information than the control group ($M = 7.95$, $SD = 2.80$, $d = 0.25$). There was no significant difference in strategy application between the control group and the personalization group ($M = 7.73$, $SD = 2.79$, $d = 0.07$.

The effects of strategy instruction on multimedia group: An interaction analysis

The interaction analysis between strategy instruction group and multimedia group provides some additional clarity to the previous main effect findings. The strategy instruction group X multimedia group interaction was significant for recall (see Table 1), $F(2,359) = 3.77$, $MSE = 3.93$, $p = .02$. Examination of this interaction indicates that participants in the segmentation group recalled more in the comprehensive condition, than the superficial condition, while participants in the control and personalization groups recalled more in the superficial condition, than the comprehension condition. To explore these differences further, a one-way ANOVA examining multimedia group (i.e., control, segmentation, personalization) within the superficial strategy instruction group revealed no significant differences in recall, $F(2,160) = 0.42$, $MSE = 0.17$, $p = .95$. However, a one-way ANOVA examining multimedia group within the comprehensive strategy instruction group revealed significant differences for recall, $F(2,199) = 10.63$, $MSE = 39.23$, $p = .00$; specifically, the segmentation group recalled more information than either the control group ($p = .00$, $d = 0.72$) or the personalization group ($p = .00$, $d = 58$). These additional findings would seem to indicate that participants in the comprehensive-segmented group recalled more than all other participants. This conclusion was tested using a contrast analysis to compare the comprehensive-segmented group to the remaining five groups (i.e., superficial-control, superficial-segmented, superficial-personalization, comprehensive-control, comprehensive-personalization). This contrast was significant, $F(1,359) = 14.17$, $MSE = 3.93$, $d = .50$, $p = .00$, indicating that the comprehensive-segmented group recalled more information than any other group.

In addition, the strategy instruction group X multimedia group interaction was also significant for strategy application (see Table 1), $F(2,359) = 3.86$, $MSE = 6.11$, $p = .02$. Examination of this interaction indicates that participants in the segmentation group had a larger difference in application scores between the superficial and comprehensive conditions than the control and personalization groups. To explore these differences further, a one-way ANOVA examining multimedia group (i.e., control, segmentation, personalization) within the superficial strategy instruction group revealed no significant differences in strategy, $F(2,160) = 0.39$, $MSE = 1.32$, $p = .67$. However, a one-way ANOVA examining multimedia group within the comprehensive strategy instruction group revealed significant differences in strategy application, $F(2,199) = 6.59$, $MSE = 54.85$, $p = .00$; specifically, the segmentation group applied more strategy information than either the control group ($p = .00$, $d = 0.52$) or the personalization group ($p = .00$, $d = 0.59$). These additional findings would seem to indicate that participants in the comprehensive-segmented group applied more strategy information than all other participants. This conclusion was tested using a contrast analysis to compare the comprehensive-segmented group to the remaining five groups. This contrast was significant, $F(1,359) = 27.73$, $MSE = 6.11$, $d = 1.06$, $p = .00$, indicating that the comprehensive-segmented group applied more strategy information than any other group.

DISCUSSION

The present study was designed to assess the validity of the segmentation and personalization principles in superficial and comprehensive strategy instruction environments. Specifically, the purpose of the study was to determine the generalizability of the segmentation and personalization effects in a comprehensive strategy instruction environment given that previous re-

search (Mayer & Chandler, 2001; Moreno & Mayer, 2004) has focused on assessment in only short, simplistic multimedia environments.

The results of the present study extend and are in general agreement with current guidelines and previous research on strategy instruction that indicate that students who engage in strategy instruction involving explicit explanations, expert modeling, extensive examples, and practice with feedback learn to understand and apply the strategy more readily than students who engage in strategy instruction that includes only general explanations (Alfassi, 2004; Collins Block & Pressley, 2002; Pani, 2004; Pressley & Woloshyn, 1995). The findings indicated that while students learned to recall a strategy equally in multimedia-based superficial and comprehensive instructional strategy environments, in order to apply the strategy well, students must have engaged in a comprehensive instructional strategy environment. Thus, in order to foster a deeper understanding and application of a strategy within a multimedia-based environment, students must engage in strategy instruction at a more comprehensive level.

The results, however, do not support a generalizable segmentation principle, but rather a more nuanced interpretation. Specifically, the segmentation principle had no significant effect on recall or application in the superficial strategy instruction environment, but did have a significant effect on both recall and application in the comprehensive strategy instruction environment. These results are in accordance with the results of Mayer and Chandler (2001) who assessed the segmentation principle with students engaging in a short lightning formation multimedia tutorial and found that students who engaged in the segmented tutorial transferred, but did not recall, more information than students who engaged in a non-segmented tutorial. In both cases, Mayer and Chandler (2001) and the current study, a segmentation effect was not found for recall, but was found for a deeper measure of understanding, transfer and application, respectively. These findings provide evidence that segmentation is most effective when deep learning, rather than shallow learning, is the instructional goal.

These findings support the premise that the basis of the segmentation principle is the alleviation of cognitive load (Mayer, 2005; Mayer & Chandler, 2001). In the superficial instructional strategy environment, where the strategy content was low, segmenting had no effect. However, in the comprehensive instructional strategy environment, where the strategy content was high, segmenting was effective in increasing both strategy recall and application. Thus, segmentation provides a valid approach to reducing cognitive load so that the learner may engage in the necessary cognitive processing to make sense of the instruction.

The current study, however, provides no support for the personalization principle, that students will learn better from multimedia tutorials with verbal content in a conversational, rather than formal, tone (Mayer, 2005a). Across both superficial and comprehensive strategy instruction environments, students in the personalization group recalled and applied the instructional strategy equal to, but not better than, the control group. These findings are in direct opposition to the findings of Moreno and Mayer (2000 [Exps 3-5], 2004) who found that students who engaged in a personalized multimedia biological plant-construction simulation had significantly better recall and transfer that students who engaged in a non-personalized simulation. In addition, Moreno and Mayer (2000, Exps 1-2) and Mayer et al. (2004) found that students who engaged in a personalized multimedia tutorial addressing lightning formation had significantly better transfer, but not recall, than students who engaged in a non-personalize tutorial. An explanation for the lack of a personalization effect in the present study is elusive given that the personalization effect was not present in either the short and simplistic superficial strategy instruction environment or the long and complex comprehensive strategy instruction environment.

The reported findings have important ramifications for the design of multimedia instruction. The central application is that students will learn more deeply from longer and more complex multimedia tutorials that provide segmentation; that is, control over the pacing of the instruction. This pacing control seems to provide the students with the time to activate and implement the cognitive resources necessary to learn deeply. The present findings, however, also call for caution in personalizing multimedia tutorials. Given the limited number of previous studies regarding multimedia-based personalization (Moreno & Mayer, 2000, 2004, Mayer et al., 2003), the present results call into question the generalizability of the personalization effect.

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