THE EFFECT OF SEMANTIC MAPS AND DIFFERENT ADJUNCT PROCESSING STRATEGIES ON STUDENT ACHIEVEMENT OF DIFFERENT TYPES OF LEARNING OUTCOMES

A Thesis in

Instructional Systems

by

Kelly Ann Chiemi Yamashiro

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Submitted in Partial Fulfillment of the Requirements for the Degree of

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We approve the thesis of Kelly Ann Chiemi Yamashiro.

Date of Signature

Francis M. Dwyer
Professor of Education
Thesis Advisor
Chair of Committee

Kyle L. Peck
Professor of Education

Carol A. Dwyer
Affiliate Associate Professor of Education

Edgar P. Yoder
Professor of Agricultural and Extension Education

Alison A. Carr-Chellman
Associate Professor of Education
In Charge of Graduate Programs in Instructional Systems
ABSTRACT

The purpose of this study was to determine the effects of different adjunct processing strategies in complementing semantic maps embedded within instructional text on student achievement of different types of learning outcomes. The adjunct strategies used to complement embedded semantic maps were adjunct post-questions, metacognitive process prompts, and cognitive feedback. The 270 participants in this study were Taiwanese undergraduate students majoring in English as a foreign language at a private institute of technology in Taiwan.

Subjects were divided into two groups—Group A and Group B. Subjects in each group were randomly assigned to one of four treatment subgroups—Treatment 1 received computer-based instructional text with embedded semantic maps; Treatment 2 received computer-based instructional text with embedded semantic maps and adjunct post-questions; Treatment 3 received computer-based instructional text with embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and Treatment 4 received computer-based instructional text with embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback. Prior to receipt of the computer-based instruction, subjects in Group A were not given strategy training on semantic maps and metacognitive process prompts, but subjects in Group B received one hour of strategy training on semantic maps and, if applicable, one hour of strategy training on metacognitive process prompts. Upon completion of the computer-based instruction, all subjects were given three multiple-choice tests to measure
immediate achievement on three different learning outcomes. One week later, all subjects were given the same three multiple-choice tests to measure delayed achievement on the three different learning outcomes.

Multivariate analysis of variance revealed no significant differences in both immediate testing and in delayed testing on the criterion tests' scores among the varied semantic map treatments regardless of whether strategy training was or was not provided. However, a doubly repeated measures multivariate analysis of variance revealed that the main effect within-factor variable of time was significant. Further analysis using one-sample t tests revealed that several test score difference values were not significantly different from zero, indicating that several test scores achieved in immediate testing were not significantly different from those achieved one week later in delayed testing.

From the results, it was concluded that the costs to develop and administer the strategy training could be saved because the training on semantic maps and metacognitive process prompts did not significantly improve students' immediate and delayed achievement on the three learning outcomes. However, it was thought that if more training was provided that included practice on using the strategies, the results might have favored those who received strategy training. It was also concluded that the combination of empirically and theoretically based strategies does not necessarily enhance learning. The effectiveness of such strategies may be realized when used alone. However, when used in combination, the theoretical functions might interact with one another to the point of creating either an innocuous or an adverse effect on achievement.
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Chapter 1

INTRODUCTION

Graphic organizers are spatial displays of text incorporated into the instructional text to communicate vertical, horizontal, hierarchical, or coordinate relationships among concepts (Robinson, Katayama, Dubois, & Devaney, 1998). They are inserted into text in an attempt to aid learning. Researchers (e.g., Jonassen, Beissner, & Yacci, 1993 and Winn, 1990) have noted that over the last several years, advances have been made in computer software that allow instructors and text designers to more easily create and embed graphic organizers, such as concept maps, diagrams, and semantic maps, into text. For example, software such as Inspiration and Visio provide the user not only with several templates of graphic organizers, but also with features that allow the user to more easily manipulate the graphic organizers. The Visio software also allows graphic organizers to be exported as image files (e.g., JPEG or GIF files) so that they may be imported into word processing documents or embedded in HTML files with text. Another example is the expanded capability of MS Word and PowerPoint to allow the user to easily create and embed graphic organizers into text through the use of "AutoShapes" and drawing tools.
Statement of the Problem

Not only have advances in technology permitted those with little knowledge of text design to more easily develop and incorporate graphic organizers into text (Winn, 1990), but it has also allowed authors of instructional text to more readily use graphic organizers with the intent of assisting learners to more effectively learn from text materials (Robinson, 1998). However, while graphic organizers are believed to enhance text learning, some researchers (e.g., Dunston, 1992; Rice, 1992; and Robinson, 1998) maintain that research on graphic organizers has not brought about a clear consensus as to the types of graphic organizers that are most effective and has not provided clear explanations as to why they may or may not be effective. In addition, most graphic organizer research over the last two decades has focused on student-constructed graphic organizers as opposed to researcher-constructed graphic organizers (as adjunct aids to text), so few studies on the effects of embedded graphic organizers exist (Robinson, 1998).

Researcher-constructed semantic maps, the type of graphic organizer used in this study, focuses on the hierarchical relationships among categories of concepts (Jonassen et al., 1993; Roshan, 1997). This organization of information and ideas is believed to help a learner relate new information to prior knowledge (Ward, 1988). Thus, semantic maps are thought to particularly aid vocabulary acquisition in which new concepts can be related to a learner's prior knowledge, thereby enhancing reading comprehension (Jonassen et al., 1993). The organization and structure of information that semantic maps provide are also believed to facilitate the recall of information (Glynn & DiVesta, 1977).
However, research on semantic maps in general is mixed. In addition, congruent to what Robinson (1998) has stated about graphic organizer research, few studies have focused on researcher-generated semantic maps. More evidence appears to be needed to corroborate the benefits that semantic maps are thought, in theory, to provide.

Not only has research on semantic maps in general been mixed, but the research on embedded semantic maps has focused on this particular strategy alone as opposed to complementing them with other adjunct aids. It could be that depending upon the interaction of other adjunct aids with embedded semantic maps, the efficacy of these maps may or may not be realized. Because semantic maps are a type of rehearsal strategy, their effectiveness may depend on what is being done with rehearsal during learning (Craik & Lockhart, 1972). Since embedded graphic organizers in text instruction limit control over the interaction that the learner has with them, it may be that only when the learner has interacted with and reviewed them at a particular level, can graphic organizers aid learning and increase performance (Roshan, 1997).

**Purpose of the Study**

The purpose of this study was to determine the effects of different adjunct processing strategies in complementing semantic maps embedded within instructional text on student achievement of different types of learning outcomes. Specifically, it sought to examine the effects of adjunct post-questions, metacognitive process prompts, and cognitive feedback in complementing semantic maps embedded within an expository text passage on the immediate and delayed achievement of three types of learning
outcomes: 1) knowledge of specific facts, terms, and definitions; 2) ability to identify parts or positions of an object; and 3) understanding of complex procedures and processes, when training on semantic maps and metacognitive process prompts is and is not provided to learners.

**Significance of the Study**

Advancements in computer software allow instructional designers and authors of instructional text to more easily create and embed graphic organizers, such as semantic maps, into text materials. Semantic maps are believed to assist the learner in recalling information and relating new information to prior knowledge (Glynn & DiVesta, 1977; Ward, 1988). However, research on embedded semantic maps has not provided a clear consensus on its effectiveness. One possibility for this is that graphic organizer research has tended to focus on factual information acquisition rather than more conceptual information acquisition. Graphic organizers' spatial arrangement makes it more advantageous to displaying not only facts, but particularly relationships among facts, as well as the organization of concepts (Robinson, 1998). Therefore, like Roshan's (1997) investigation, this study will focus on improving performance of different learning outcomes, not only at the factual information acquisition level, but also at the concept and principle acquisition levels.
Another possible explanation for the inconsistent findings surrounding research on graphic organizers and semantic maps is that the efficacy of the embedded strategies may not be realized due to learners' limited interaction with them (Roshan, 1997). Roshan's (1997) investigation produced no significant difference in learner performance between semantic maps and a text-only control group, but she believed that if learners were provided more in-depth interaction with embedded maps, their performance would significantly increase. Since embedded semantic maps' efficacy may depend on learners' quality of interaction with them, additional instructional strategies may allow for more in-depth interaction with semantic maps, and thereby possibly significantly increase learner performance. Therefore, additional strategies (adjunct post-questions, metacognitive process prompts, and cognitive feedback) were used in this study to allow for more interaction with the embedded semantic maps and instructional text.

Not only should this study help instructional designers and authors of instructional text to decide whether or not additional instructional strategies should be used to complement semantic maps for specific learning outcomes, but this study should also help them understand the more long-term effects of complementing semantic maps with additional strategies because both immediate and delayed achievement of learning outcomes were examined. Both Robinson (1998) and Roshan (1997) have suggested that delayed testing be incorporated in graphic organizer research, not only because most embedded graphic organizer research has only looked at immediate testing results, but more importantly because it is the long-term learning results that are useful to both researchers and practitioners.
Theoretical Justification

Semantic maps and the additional strategies (post adjunct questions, metacognitive process prompts, and cognitive feedback) used in this study can be classified under such instructional strategies as graphic organizers, questions, reflective thinking strategies, and feedback, accordingly. While empirical evidence exists to support the use of graphic organizers (e.g., Robinson, 1998), questions (e.g., Hamilton, 1985), reflective thinking strategies (e.g., Chi, Bassok, Lewis, Reimann, & Glaser, 1989), and feedback (e.g., Bangert-Drowns, Kulik, Kulik, & Morgan, 1991), mixed results have also been found for graphic organizers (e.g., Roshan, 1997), questions (e.g., Hamaker, 1986), reflective thinking strategies (e.g., Davis, 1996), and feedback (e.g., Kluger & DeNisi, 1996). This indicates that to make an assumption of a general facilitative effect for any of these strategies would be erroneous. Unfortunately, however, researchers (e.g., Kluger & DeNisi, 1996 and Robinson, 1998) have noted the widespread acceptance of such assumptions (e.g., feedback consistently improves performance or graphic organizers facilitate learning) not only in the community of practitioners, but in the research community as well. Investigators of each strategy have begun to voice the need for fellow researchers to examine not only which strategy forms are effective (e.g., embedded versus student-constructed semantic maps, factual versus higher-order post-questions, and outcome versus cognitive feedback), but also when (e.g., under what conditions, with which learners, and for which intended and measured learning outcomes) as well as why (e.g., what processing is induced and what makes it effective) (Berardi-Coletta, Dominowski, Buyer, & Rellinger, 1995; Butler & Winne, 1995; Hamaker, 1986;
Hamilton, 1985; Kluger & DeNisi, 1996; Lin, Hmelo, Kinzer, & Secules, 1999; Robinson, 1998; Roshan, 1997). This additional knowledge can then be used to restructure and advance the theories behind each strategy. When theories lag so that inconsistent findings in the literature cannot be integrated, as Kluger & DeNisi (1996) note has been the case for feedback theories, this poses serious implications for practitioners who are responsible for ensuring that learning occurs and for researchers who are responsible for not only providing practitioners with the empirical evidence upon which to base decisions, but also for adding to the conceptual and theoretical development of concepts in the field.

Based on the need to understand which strategies are effective and when, as well as to better determine why they may be effective or ineffective under particular circumstances, Hamilton's (1985) framework was used to select the strategies for this study. Strategies were selected based on their intended learning outcomes (levels of processing and focus assumed to be induced) for the measured learning outcomes (levels of processing and focus that the criterion measures required). Table 1.1 presents the measured and intended learning outcomes for each strategy used in this study. The intended learning outcomes listed in Table 1.1 are explained in the literature review in Chapter 2.
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<th>Intended</th>
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<td>• Knowledge of specific facts, terms, and definitions as measured by the Terminology Test</td>
<td>• Visual argument/Computational efficiency (Larkin &amp; Simon, 1987; Waller, 1981)</td>
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<td>• Ability to identify parts or positions of an object as measured by the Identification Test</td>
<td>• Selective attention to terms and relationships (Mayer, 1984)</td>
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<td>• Internal connections (Mayer, 1984)</td>
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<td>• Conjoint retention/dual encoding (Kulhavy, Lee, &amp; Caterino, 1985; Kulhavy, Stock, Peterson, Pridemore, &amp; Klein, 1992; Paivio, 1983)</td>
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<tr>
<td>Adjunct Post-Questions</td>
<td>• Knowledge of specific facts, terms, and definitions as measured by the Terminology Test</td>
<td>• Focusing effect/pacing (Frake, 1968; Rickards &amp; DiVesta, 1974)</td>
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<td></td>
<td>• Ability to identify parts or positions of an object as measured by the Identification Test</td>
<td>• Specific backward processing (Rickards &amp; Denner, 1978)</td>
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<td>• Understanding of complex procedures and processes as measured by the Comprehension Test</td>
<td>• Distinctiveness of encoding for deeper processing (Jacoby &amp; Craik, 1979)</td>
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<td>• Extent of elaboration for deeper processing (Benton, Glover, &amp; Bruning, 1983)</td>
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<td>Metacognitive Process Prompts</td>
<td>• Understanding of complex procedures and processes as measured by the Comprehension Test</td>
<td>• Metacognitive processing (Berardi-Coletta et al., 1995; Berry, 1983; Berry &amp; Broadbent, 1984; Dominowski, 1990; Gagne &amp; Smith, 1962)</td>
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<td>• Internal feedback (Butler &amp; Winne, 1995)</td>
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<td>Cognitive Feedback</td>
<td>• Understanding of complex procedures and processes as measured by the Comprehension Test</td>
<td>• Attention to cues relation to successful performance (Balzer et al., 1989; Butler &amp; Winne, 1995)</td>
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<td>• Comparison of one's own processing to that of an expert (Lin et al., 1999)</td>
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</table>
Definition of Key Terms

The following are definitions of terms used in this study.

**Adjunct processing strategies** - Techniques incorporated into the instructional text that assist learners in the acquisition and retention of knowledge.

**Adjunct questions** - Questions incorporated into the instructional text with the intention of influencing what is learned from the text (Hamaker, 1986).

**Cognitive feedback** - A type of feedback intervention that contains information from which learners can link cues to achievement (Balzer, Doherty, & O’Conner, 1989).

**Feedback intervention** - “…actions taken by (an) external agent(s) to provide information regarding some aspect(s) of one’s task performance” (Kluger & DeNisi, 1996, p. 255).

**Graphic organizers** - Spatial displays of text incorporated into the instructional text to communicate vertical, horizontal, hierarchical, or coordinate relations among concepts (Robinson et al., 1998).

**Metacognition** - An ability in which one is able to reflect on one’s learning process, understand it, and also control it (Schraw & Dennison, 1994).
Metacognitive process prompts - Process prompts that pose questions specific to the learner’s metacognitive processes, such as organizing, monitoring, or evaluating his own learning (Lin et al., 1999).

Process prompts - A questioning strategy that focuses the learner’s attention on particular processes as learning takes place in order to elicit reflective thinking (Lin et al., 1999).

Reflective thinking - Actively organizing, monitoring, evaluating, and modifying one’s learning to gain a better understanding of one’s performance (Lin et al., 1999).

Reflective thinking strategies - Techniques that assist learners in reflective thinking.

Semantic maps - A type of graphic organizer that visually represents hierarchical relationships among categories of concepts (Jonassen et al., 1993; Roshan, 1997).

Research Questions

This study addressed the following research questions:

1) When training on strategies (semantic maps and metacognitive process prompts) is and is not provided to learners, do semantic maps complemented by different adjunct
processing strategies (adjunct post-questions, metacognitive process prompts, and cognitive feedback) differentially effect achievement of:

a) knowledge of specific facts, terms, and definitions?

b) ability to identify parts or positions of an object?

c) understanding of complex procedures and processes?

2) Within each of the four semantic map treatments, when training on strategies (semantic maps and metacognitive process prompts) is and is not provided to learners, is there a significant difference between immediate and delayed achievement of:

a) knowledge of specific facts, terms, and definitions?

b) ability to identify parts or positions of an object?

c) understanding of complex procedures and processes?

The four semantic map treatments were identified as a. embedded semantic maps only; b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

**Hypotheses**

Due to the mixed results of prior research on the different adjunct strategies used in this study and the lack of empirical research on their combined effects, the following hypotheses were offered for the previously stated research questions.
Hypothesis 1

H₀: There will be insignificant differences in the immediate and delayed achievement of different learning outcomes across the varied semantic map treatments when training on strategies (semantic maps and metacognitive process prompts) is and is not provided to learners. The different learning outcomes were defined as a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an object; and c. understanding of complex procedures and processes, while the varied semantic map treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

Hypothesis 2

H₁: Within each of the four semantic map treatments, there will be significant differences between the immediate and delayed achievement of different learning outcomes when training on strategies (semantic maps and metacognitive prompts) is and is not provided to learners. The different learning outcomes were defined as a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an object; and c. understanding of complex procedures and processes, while the varied semantic map treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.
questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

**Generalizability of the Study**

The students who participated in this study were Taiwanese undergraduate students majoring in English as a foreign language at a private institute of technology in Taiwan. Students were not compensated for their participation, nor was the instructional content used in the study related to their coursework, so students may have lacked the interest and motivation to fully participate in this study. However, since the instructional content described the structure and function of the human heart, it may have been of interest to some participants. Because some of the students in this study received a short training session on semantic maps and, if applicable, metacognitive prompts a week prior to encountering the instructional content on the human heart, the results of this study should be generalizable to similar groups of college students who may or may not be familiar with semantic maps and the adjunct processing strategies (adjunct post-questions, metacognitive process prompts, and cognitive feedback) that were used to complement the semantic maps.

**Organization of the Study**

The study is presented in a traditional format such that
• Chapter 2 reviews the literature related to semantic maps, adjunct questions, metacognitive prompts, and feedback;

• Chapter 3 describes the design of the study, including the materials and instrumentation used;

• Chapter 4 presents the results of the study; and

• Chapter 5 presents the findings, conclusions, and recommendations.
Chapter 2

REVIEW OF THE LITERATURE

This chapter provides an overview of cognitive information processing as the theoretical basis for the study and then examines the literature on the instructional strategies used in this study--semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback. For each instructional strategy, a description, review of the literature, and explanation of the intended learning outcomes introduced in Table 1.1 in Chapter 1 are provided.

Information Processing

Atkinson and Shiffrin (1968) believed that when information is received by the human information processing system, in order for it to be permanently stored into memory, it must undergo a series of transformations. Their model was the first multistore, multistage model which explained learning in this manner (Driscoll, 2000; Smith & Ragan, 1999). This conception of learning as information processing can be displayed as a model consisting of structures and processes (Driscoll, 2000; Gagne & Driscoll, 1988, p. 13; Smith & Ragan, 1999, p. 20), as shown in Figure 2.1.
The sequential stages in which information is processed are linked to the sensory register, working memory, and long-term memory with the executive control managing the processing of information (Gredler, 1997). The sensory receptors, or senses, are activated by the stimuli from the individual's environment, and information is then transmitted to the central nervous system. Next, information is briefly registered with one of the sensory registers and undergoes a transformation, known as selective perception, into patterns that can be recognized by working memory. Information must be rehearsed in order to be maintained in working memory so that it can be encoded for storage in long-term memory. As the model shows, information in long-term memory is also retrieved into working memory for further processing (Gagne, Briggs, & Wager, 1992). More detail on the stages and processes in the model follows.

*Figure 2.1: Information Processing Model*
Sensory Register

Sperling (1960) demonstrated the existence of the sensory register (also known as immediate or sensory memory), which represents the first stage of information processing. The sensory register is primarily sensitive to visual and auditory environmental stimuli. When information impinges upon the sensory register, it is: 1) never processed, 2) only briefly retained, or 3) processed and continues to the next component of the model (Gredler, 1997). Since information can only reside in the sensory register for an extremely brief period, the individual must choose to attend to the information if it is to continue on for further processing.

Working Memory

Working memory is the stage in which the conscious processing of stimuli received from the environment occurs (Driscoll, 2000). Information that is selectively attended to is in an active state. When information, or concepts, are active, concepts can become connected to related concepts in order for learning to occur (Gredler, 1997). While attention is needed, it does not suffice for the processing of information. Stimuli from the environment must also be recognized as previously learned concepts, the process known as pattern recognition (Driscoll, 2000).

Working memory is limited by the amount of information that can remain active at any one time, which is determined by not only the amount of information being worked upon, but also by the processes that are acting upon the information. About seven
plus or minus two units of information can be held in working memory (Miller, 1956). This is based on Miller's (1956) classic experiment in which subjects had to recall numbers in a digit-span test. However, the more effortful the work being done on the information, the more limiting working memory becomes, while the less effortful and more automatic the work, the less limiting working memory becomes. In addition, if information is not rehearsed, it will disappear from working memory in about 15 to 30 seconds (Brown, 1958; Gagne et al., 1992; Peterson & Peterson, 1959).

**Long-Term Memory**

Depending upon if and how information in working memory is acted upon, it may become information that is inactive yet permanent. Long-term memory is this inactive state of previously learned concepts (Gredler, 1997). Klatzky's (1980) conception of long-term memory is that of a mental dictionary of concepts and their associations to each other. Unlike working memory, the capacity of long-term memory is unlimited, and information in long-term memory is not subject to decay (Smith & Ragan, 1999).

**Encoding and Retrieval**

Learning involves reorganizing previously learned concepts that are stored in long-term memory and not just the taking in of all new concepts. The reorganization, or transformation, occurs in working memory where encoding, the preparation of information for storage in long-term memory, and retrieval, the process through which
information is recalled from long-term memory, occurs (Gagne et al., 1992; Gredler, 1997). In working memory, information is manipulated, transformed, incorporated, integrated, or interpreted with previously learned concepts, or prior knowledge, from long-term memory in order to encode the information for later retrieval. When this takes place and information is encoded in long-term memory, the information becomes meaningful (Gagne et al., 1992; Smith & Ragan, 1999).

When information is intentionally processed to be stored in long-term memory, it can either be superficially or meaningfully processed. Less meaningful processing occurs through primary or maintenance rehearsal--rote rehearsal involving repeatedly reciting information. Not much meaning is assigned to it because not much is done with or to the information, and the effects of maintenance rehearsal are often only temporary (McKeown & Curtis, 1987). In elaborative rehearsal, several acts can occur with the information that allow for more deep processing, and therefore, more reliable retrieval (Driscoll, 2000). Information can be changed, modified, or transformed in order for it to relate to the learner's prior knowledge, it can be elaborated on or supplemented with previously learned concepts, and it can be replaced by other concepts (Gredler, 1997; Tulving & Madigan, 1970).

Previously learned concepts can be thought of as nodes which are linked or interconnected to each other. These interconnections represent the learned relationships (Collins & Quillian, 1969). In order for previously learned concepts in long-term memory to be retrieved, or activated into working memory, to be linked to either new concepts or other previously learned concepts so that learning can occur, a retrieval cue or stimulus
from the environment must be present to initiate the spread of activation. The spread of activation is an automatic process that occurs when a concept becomes active and then activates other linked concepts that are related to it. It allows previously learned concepts to be activated into working memory in order for association to occur between them as well as with any new concepts. Since working memory is limited, what is retrieved from long-term memory are the more strongly linked concepts, or the concepts that are more meaningfully linked to the initial concept. The strength of association between concepts affects what is most likely to be retrieved. In other words, the likelihood of the information being recalled depends upon how deeply it was processed such that the more deeply the information is processed, or the more the meaning that is assigned to it, the more reliable it will be recalled (known as the depth of information processing) (Craik & Lockhart, 1972).

**Executive Control**

The processing of information is managed by an executive control. The executive control tracks the information, decides which activities should be performed, directs competing tasks, and monitors cognitive functions (Gredler, 1997).

**Semantic Maps and the Adjunct Processing Strategies Used to Complement Them**

As stated in Chapter 1, Hamilton's (1985) framework was used to select the strategies for this study. Strategies were selected based on their intended learning
outcomes (levels of processing and focus assumed to be induced) for the measured learning outcomes (levels of processing and focus that the criterion measures required) presented in Table 1.1 in Chapter 1. For the remainder of Chapter 2, a description, review of the literature, and explanation of the intended learning outcomes are provided for each instructional strategy (semantic maps, adjunct questions, metacognitive process prompts, and cognitive feedback).

**Semantic Map Strategy**

**Graphic Organizers**

Graphic organizers are spatial displays of text incorporated into the instructional text to communicate vertical, horizontal, hierarchical, or coordinate relations among concepts (Robinson et al., 1998). They are inserted into text in an attempt to aid learning. Like some other adjunct aids (e.g., advance organizers and outlines), the intent of graphic organizers is to communicate to the learner not only which information is important, but also how the textual information is structured. More specifically, it is designed to help learners understand relationships between concepts through the spatial display of information (Robinson, 1998). Because they organize information and ideas, they are believed to help learners relate new information to prior knowledge (Ward, 1988). The organization and structure of information has also been shown to facilitate recall of information (Glynn & DiVesta, 1977).
Semantic Maps

Semantic maps are a type of graphic organizer that visually represents hierarchical relationships among categories of concepts (Jonassen et al., 1993; Roshan, 1997). They contain a key concept, or main idea, with categorized concepts related to the key concept. They can be used either as advance or post organizers to improve reading comprehension and are useful in making distinctions among types of information (Jonassen et al., 1993). Figure 2.2 displays the structure of semantic maps while Figure 2.3 provides an example of a semantic map.

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Figure 2.2: Structure of a Semantic Map
Figure 2.3 shows different concepts (e.g., "Automobile," "Bicycle," and "Train") that have been grouped into a specific category (e.g., "Land"). All of the concepts are related to a main or central idea, in this case, "Types of Transportation."

The research regarding embedded semantic maps in general is mixed. Johnson, Toms-Bronowski, and Pittelman (1982) found that semantic maps were more effective than traditional methods in teaching vocabulary. Eylon and Reif (1984) found that
learners performed better at recall and problem-solving tasks when information was presented to them hierarchically, as in semantic maps, versus in a single, detailed level. Their findings corroborate earlier research studies (Bower, Clark, Lesgold, & Winzenz, 1969; Brosey & Shniederman, 1978; Glynn & DiVesta, 1977) that found that hierarchical presentation of information improves memorization. However, a more recent study (Roshan, 1997) found no significant differences in achievement among a text-only control group and varied map treatments which included semantic maps. In fact, Roshan (1997) notes that the mapping strategies used were found to confuse the learner.

For studies that did not show that hierarchically organized information, as found in semantic maps, could help learners, it might have been due to the individual differences of their subjects. For example, while Eylon and Reif (1984) found that learners performed better using semantic maps, they also found that only high achieving learners benefited from this strategy. Low achieving learners were shown not to have benefited from it.

Roshan's (1997) findings may also be explained by Beasley's study (1994). In Beasley's study (1994), spider maps, a type of map also used in Roshan's study (1997), did not always decrease learners' feelings of disorientation and may have, in fact, increased them. Most importantly, Beasley (1994) found that when learners' feelings of disorientation within a learning environment increased, their knowledge acquisition decreased. Thus, Roshan (1997) may not have found significant differences in her study because the confusion that her subjects experienced may have negatively affected their knowledge acquisition.
Although the research is somewhat mixed regarding semantic maps, semantic maps were selected for use in this study for several reasons. First, Jonassen et al. (1993) state that the semantic mapping strategy is easy to learn and clearly illustrates hierarchical relationships between concepts. Secondly, in Beasley's study (1994), unlike other maps, semantic maps, were shown to actually decrease learners' feelings of disorientation. Third, although Roshan's research (1997) did not find significant differences in achievement among students who used the different types of maps (spider maps, frame maps, and semantic maps), because the results indicated a potential for significant differences on the semantic map learning strategy, Roshan (1997) suggested combining the semantic maps with learning strategies different from the ones used in her study. Finally, semantic maps were selected based on the appropriateness of their intended learning outcomes for the measured learning outcomes used in this study (see Table 1.1 in Chapter 1). This last point is discussed in the next section.

Intended Learning Outcomes of Semantic Maps

Visual argument and computational efficiency were listed in Table 1.1 in Chapter 1 as intended learning outcomes for semantic maps. Visual argument and computational efficiency suggest that two-dimensional displays of information allow learners to quickly and easily see relationships that are obscured in one-dimensional displays (e.g., text). Visual argument involves the transmission of ideas through the spatial arrangement of words (Waller, 1981). It is believed that by "seeing" ideas, the information processing effort is reduced as compared to that which would be required to discover complex
relations in linear text (Robinson, 1998). Similar to visual argument is computational efficiency. Computational efficiency says that the efficiency with which information is processed depends on the display or layout of the information such that when learners are reading one-dimensional, linear displays, such as text, more cognitive resources are required to search for answers while fewer resources are needed when the information is presented in two-dimensional forms, such as diagrams (Larkin & Simon, 1987). In text, the learner's search for answers is an iterative process in which the learner searches for a relevant fact and while searching for the next relevant fact, the previously found fact is held in memory. This process is repeated until the answer is obtained. However, for two-dimensional displays, the search for answers is thought to be more efficient because subsequent relevant facts should be found next to each other, thereby reducing the duration of the search and allowing relevant facts about a concept to be seen simultaneously. Thus, comprehension should be facilitated with two-dimensional displays as opposed to linear displays because fewer cognitive resources are needed (Larkin & Simon, 1987; Robinson, 1998). Based on visual argument and computational efficiency, it was thought that semantic maps, as a type of two-dimensional display, could promote the encoding of relationships or concepts, thereby facilitating a learner's ability to identify parts or positions of an object as measured by the Identification Test.

Selective attention to terms and relationships was listed in Table 1.1 as another intended learning outcome for semantic maps. Graphic organizers repeat important information found in the text they accompany. This cues the learner to pay attention to the repeated information (Mayer, 1984). Therefore, it was thought that semantic maps,
being a type of graphic organizer, could aid a learner in selectively attending to the important terms and relationships found in the maps, thereby facilitating a learner's ability to recall knowledge of specific facts, terms, and definitions as measured by the Terminology Test as well as to identify parts or positions of an object as measured by the Identification Test.

Another intended learning outcome for semantic maps that was listed in Table 1.1 in Chapter 1 is internal connections. Internal connections refers to the idea that the recall of one idea found in a graphic organizer may cue the recall of related ideas because the graphic organizer displays relationships or connections (Mayer, 1984). Therefore, it was thought that semantic maps, a type of graphic organizer, could facilitate a learner's ability to recall specific facts, terms, and definitions, as measured by the Terminology Test, and parts or positions of an object, as measured by the Identification Test.

Conjoint retention and dual encoding were listed in Table 1.1 in Chapter 1 as the last intended learning outcomes for semantic maps. In a spatial display of textual information, information is dually encoded (verbally and spatially) in memory (Paivio, 1983). Conjoint retention states that because information is dually encoded, spatial encoding can serve as a backup when the verbal retrieval of information fails, thus increasing the probability of text recall of related information (Kulhavy et al., 1985, 1992). Therefore, it was thought that semantic maps, which spatially display textual information, could promote dual encoding, thereby facilitating a learner's ability to recall knowledge of specific facts, terms, and definitions, as measured by the Terminology Test, and parts or positions of an object, as measured by the Identification Test.
Adjunct Questions

Adjunct questions are questions incorporated into the instructional text with the intention of influencing what is learned from the text (Hamaker, 1986). Research on adjunct questions has focused on the type or level of information asked by the question, the position of the question within the instructional text, and the frequency with which the learner encounters the question within the text.

Previous research has shown that the type of question inserted in the instructional content can facilitate learning. Benton, Glover, Monkowski, and Shaughnessy (1983) found that when questions required learners to analyze and dissect information into associative components, memory of text was facilitated more than with questions that only required the identification and simple recall of information. However, questions requiring only the identification and simple recall of information should not be discounted since the study also found that such lower-level knowledge questions did have a facilitative effect on the recall of specific information. In addition, the study also found that, in terms of recall of information, both the lower-level knowledge questions and the higher-order questions were superior to conditions in which no questions were used. This corroborates the earlier finding by Watts and Anderson (1971) that when learners answered post-questions that required them to apply concepts or principles, the material was more deeply processed than when learners were not exposed to any adjunct questions. The tendency of higher-order questions to facilitate memory of text more than lower-level knowledge questions is also supported by Rickards and DiVesta's study (1974) which found that when post-questions required learners to organize specific facts
in relation to a general idea, learners recalled more of the text than when questions required them to focus their attention only upon specific facts or general ideas.

In terms of the positioning of questions within the instruction, Pressley and McCormick (1995) state that both prequestions and post-questions facilitate memory of text. However, this statement cannot be taken at face value as the research has shown. In one study, Rothkopf and Bisbicos (1967) found that the learning of text was facilitated by placing questions (known as post-questions) immediately after the appropriate segment of text. Learning was not facilitated when questions (known as prequestions) were placed before the text segment. Since the learning of the text was measured by a post-test, this finding would seem to pertain to the learning of relevant information as opposed to incidental information; however, this is based on the assumption that the questioned information that the adjunct questions directed the learners' attention to was also the information needed to do well on the post-test. While Rothkopf and Bisbicos (1967) did not find a facilitative effect of prequestions, Rickards (1976) found that prequestions at the conceptual level, in which learners must interrelate text statements, produced higher-level text processing than simple recall prequestions directed at specific facts from a single text statement. This was found on both the immediate and delayed tests. In addition, it was found that conceptual level prequestions were superior to conceptual level post-questions. However, Felker and Dapra (1975) found the opposite to be true.

As for the frequency of questions, Frase (1968) found that frequent exposure to factual level post-questions did produce more recall of relevant information in the text than incidental information. However, Frase (1968) was quick to note that this was not
due to an increase in relevant learning but more to a decrease in incidental learning.

Still, other researchers (e.g., Rickard & DiVesta, 1974) did not find frequent rote-learning post-questions to be effective. Instead, they found that more "meaningful learning"-type questions are more effective when they occur more frequently, possibly because, the cognitive processing of the learner is less strained when such questions are placed nearer to each other than when placed further apart.

In this study, adjunct post-questions were selected as a strategy to enhance the semantic map strategy. Upon examination of the instruction developed by Roshan (1997) for her study, it was found that semantic maps were simply incorporated into the text instruction such that much responsibility seemed to fall upon the learner to attend to the semantic maps and process its contents. If the learner did not take on this responsibility, this could be one reason why no significant differences were found in Roshan's study (1997). Therefore, it was thought that adjunct post-questions, because of its intended learning outcomes listed in Table 1.1 in Chapter 1 and discussed in the next section, would complement or enhance the semantic map strategy by providing additional guidance to learners.

**Intended Learning Outcomes of Adjunct Questions**

The more frequent the exposure to adjunct questions in the text, the greater the discrimination between recall of relevant and incidental information such that a higher level of recall of relevant information results (Frase, 1968). This effect is believed to be particularly true of "meaningful learning" post-questions as opposed to verbatim or rote
learning questions, possibly due to an increase in information processing capacity that is required when such questions are placed farther apart (Rickards & DiVesta, 1974). The focusing effect and pacing of questions were listed in Table 1.1 in Chapter 1 as intended learning outcomes for adjunct post-questions because it was thought that the higher-order adjunct questions that focus on concept relations, processes, and procedures and that appear on each screen of the computer instruction in this study could direct a learner’s attention to the relevant information needed to perform well on the Terminology and Identification Tests.

Questions can be powerful in establishing and maintaining attention (Smith & Ragan, 1999, p. 168). Although post-questions may increase review of both relevant and incidental information (Pressley & McCormick, 1995), according to Rickards & Denner (1978), adjunct questions can also elicit a specific backward processing. Specific backward processing refers to the mental review of material presented prior to the adjunct question that focuses only on the relevant material, or that which relates specifically to the question (Rickards & Denner, 1978). Specific backward processing was listed in Table 1.1 as another intended learning outcome for adjunct post-questions because it was thought that the adjunct post-questions used in this study could create a specific backward processing effect. This effect could focus a learner’s attention on the information prior to the question, which was information needed to better respond to difficult items on the dependent measures (e.g., Identification, Terminology, and Comprehension Tests), based on the item analysis conducted for the study.
Distinctiveness of encoding for deeper processing was listed in Table 1.1 in Chapter 1 as another intended learning outcome for adjunct post-questions. Distinctiveness of encoding refers to the difficulty of decisions that a learner must make during learning of new information. This difficulty may increase the chances of remembering that information (Jacoby & Craik, 1979). For example, describing similarities and differences among concepts is more difficult than identifying typical examples of concepts (Gredler, 1997). For this study, because several of the adjunct questions within the instruction required learners to make difficult decisions (e.g., describe or compare relationships or processes), the adjunct questions were thought to facilitate learners' ability to remember the information needed to better respond to difficult items on the dependent measures (e.g., Identification, Terminology, and Comprehension Tests), based on the item analysis conducted for this study.

Another aspect of deep information processing is extent of elaboration, an intended learning outcome for adjunct post-questions listed in Table 1.1 in Chapter 1. According to Benton et al. (1983), the number of ways that new information is processed may increase the chances of remembering that information. In their study, learners who recalled more idea units were those who were required to answer one to three inferential questions after reading paragraphs as compared to those who only read declarative versions of the questions. Unlike Benton et al.'s study, in this study, while a learner is asked to answer only one adjunct question, this is in addition to and subsequent to the provision of a semantic map, and both the semantic map and its corresponding adjunct question depict the new information to be learned. Therefore, it was thought that because
the adjunct question provided another way to process the new information, there could be a greater chance of remembering the information needed to better respond to difficult items on the dependent measures (e.g., Identification, Terminology, and Comprehension Tests), based on the item analysis conducted for this study.

**Metacognitive Process Prompts**

**Metacognition**

Metacognition was first defined by Flavell (1976, p. 252) as "one's knowledge concerning one's cognitive processes and products or anything related to them...among other things, to the active monitoring and consequent regulation and orchestration of these processes...usually in the services of some concrete goal or objective," or simply, "the process of thinking about thinking" (Babbs & Moe, 1983, p. 423). Later researchers elaborated upon Flavell's definition. For example, Weinstein and Mayer (1986, p. 323) added that not only is it knowledge about one's cognitive processes, but also one's "...ability to control these processes by organizing, monitoring, and modifying them as a function of learning outcomes." Schmitt and Newby (1986) stated that the cognitive processes one has knowledge about or awareness of is in relation to a task. Schraw and Dennison (1994) defined metacognition as an ability in which one is able to reflect on one's learning process, understand it, and also control it. Finally, Seifert (1995 as cited in
Kim, 1999) defined it as knowing when, how, and why to use a strategy in relation to completing a task.

Many researchers (e.g., Brown, 1987; Flavell, 1979, 1987; Jacobs & Paris, 1987; Schmitt & Newby, 1986; Schraw & Dennison, 1994) have separated metacognition into two components—knowledge about cognition and the regulation of cognition. Three subprocesses are included within knowledge about cognition—declarative knowledge, procedural knowledge, and conditional knowledge. Declarative knowledge is having knowledge about tasks and strategies that may apply to the task. Procedural knowledge is knowledge about the use of the strategies. Lastly, conditional knowledge is knowledge of when to use the strategies and why. Like the first component of metacognition, the second component, regulation or control of cognition, also includes subprocesses. They are planning, implementing, monitoring, evaluating, and prioritizing strategies (Brown, 1978; Schraw & Dennison, 1994; Shore & Dover, 1987).

Studies (e.g., Garner & Alexander, 1989; Lin, 1993; Pressley & Ghatala, 1990; Rowe, 1988) suggest that learners who are more aware of their metacognitive processes are more strategic, active, reflective, and goal oriented learners. Therefore, a growing number of researchers (e.g., Brown, 1987; Lin, 1994; Prinrich & DeGroot, 1990; and Romainville, 1994) support the use of metacognitive strategies to enhance learning. *Table 2.1* lists several metacognitive strategies.
Reflective thinking requires actively organizing, monitoring, evaluating, and modifying one’s learning in order to gain a better understanding of one’s performance (Lin et al., 1999). Recently, some researchers (e.g., Lin et al, 1999) have suggested that for learners to consciously decide upon how they should use and process the information they receive requires that they engage in reflective thought about their decision-making and problem-solving processes. In other words, learners should think reflectively and
critically in order to rationalize the relevancy and importance of the information they receive as well as to identify their difficulties in understanding the information and the remedial actions they should take when this occurs. However, these researchers (e.g., Lin, 1993 and Lin et al., 1999) have agreed that learners don't spontaneously regulate their learning, and, therefore, strategies that support reflection, such as process-probing questions, should be provided in the instruction.

Process prompts are questions that focuses the learner’s attention on particular processes as learning takes place in order to elicit reflective thinking (Lin et al., 1999). Prior research (e.g., King, 1991; Palinscar & Brown, 1984; Scardamalia & Bereiter, 1985) has found that in reading, writing, biology, and mathematics process prompts are considered to effectively support reflection. Metacognitive process prompts are a type of process prompt. They pose questions specific to the learner’s metacognitive processes, such as organizing, monitoring, or evaluating his own learning (Lin et al., 1999).

In terms of the research on metacognitive prompts, studies have tended to focus on the transfer of learning as opposed to immediate student achievement. However, one study (Garrison, 1996) did find that learners who received metacognitive prompts achieved significantly higher test scores than those who did not receive the prompts. Metacognitive prompts may help learners because, as Lin (1993) has found through qualitative analysis, the prompts make learners focus more on how they are processing information. More specifically, metacognitive prompts have been shown to encourage planning of actions and reflection on one's understanding and can increase the likelihood of learners providing rationales for their decisions (Davis, 1996), and when learners are
required to provide rationales for their actions, understanding is more likely to occur (Brown & Campione, 1986; Chi et al., 1989; Lin, 1993).

**Metacognitive Prompts and Graphic Organizers**

Research investigating the effect on learner achievement when graphic organizers are combined with metacognitive prompts is sparse. However, one study by Lee (1997) found that, when used together, concept maps, a type of graphic organizer, and metacognitive prompts did interact with each other. Their combination, however, was not significantly better, in terms of achievement on a post-test, than when each strategy was used alone. In addition, Lee did find that when the concept maps and metacognitive prompts were used alone, learner performance was significantly better than when no strategies were used at all. Through qualitative data, Lee also found that learners liked the concept maps within the instruction but were divided on the use of metacognitive prompts.

In contrast to Lee's (1997) study, this study used subjects who have not been highly exposed to the instructional content. In addition, while Lee's study (1997) focused upon the reinforcement of instructional content, this study focused upon introducing relatively new information to learners, or rather, information that learners have not immediately encountered, and it did so through the use of semantic maps instead of concept maps.
Researchers (e.g., Lin et al., 1999, pp. 44, 46) have claimed that "reflective learning environments" can efficiently enhance the aspects of reflection by ensuring that "scaffolds to enhance reflection occur as a value-added item to other aspects of learning." However, research is sparse in investigating how strategies used to enhance reflective thinking may complement other learning strategies. Lee (1997) even stated that more research examining the interaction effect between maps and metacognitive cues is needed. Therefore, metacognitive process prompts were selected for this study to investigate whether or not it can complement or enhance semantic maps and adjunct questions. It was also thought that because of its intended learning outcomes listed in Table 1.1 in Chapter 1 and discussed in the next section, metacognitive process prompts would assistance learners with their achievement of the more difficult measured learning outcome.

**Intended Learning Outcomes of Metacognitive Prompts**

Asking a learner to verbalize solutions to problems makes a learner stop and think about what he is doing or has done (Gagne & Smith, 1962). Verbalization assists in maintaining a learner's attention to important aspects of a task or problem (Berry, 1983; Berry & Broadbent, 1984). The explanation of one's actions invokes executive processes, such as attention to important task or problem features and monitoring, which can lead to performance efficiency (Dominowski, 1990). Simply verbalizing what is in one's working memory will not effect performance. However, requesting explanation of one's
actions shifts the attention from the problem aspects to the process that is being used to problem solve, and this shift in attention to the problem solving process can lead to improved performance. In other words, attention shifts to metacognitive processing in which one observes oneself as a problem solver, thereby acquiring relevant knowledge and understanding its application to the solution (Berardi-Coletta et al., 1995). According to Berardi-Coletta et al. (1995), metacognitive processing may facilitate the integration of domain and procedural knowledge (knowledge of the use of strategies). Metacognitive processing was listed in Table 1.1 in Chapter 1 as an intended learning outcome for metacognitive process prompts. In this study, because the metacognitive process prompts asked the learner to explain how he answered the adjunct post-questions or why he responded as he did to the adjunct questions in the instruction, it was thought that the metacognitive process prompts could help to focus the learner's attention on the process he used to answer the adjunct post-questions, particularly those questions that were directed at understanding complex processes and procedures, thereby facilitating his ability to understand complex procedures and processes as measured by the Comprehension Test.

Another intended learning outcome listed in Table 1.1 in Chapter 1 for metacognitive process prompts was internal feedback. When a learner monitors his learning process, he gives himself feedback, or generates internal feedback. This internal feedback can assist him in reexamining and, if needed, modifying his approach to learning to better meet his learning goals (Butler & Winne, 1995). Therefore, if the metacognitive process prompts in this study were successful at helping the learner to
monitor his learning process, then the learner may have generated internal feedback which he could use to reexamine and modify how he was learning the information needed to perform well on the Identification, Terminology, and Comprehension Tests.

**Cognitive Feedback**

Feedback is often viewed as information that follows a learner's response (Kulhavy & Wager, 1993; Wager & Wager, 1985). The intent of the feedback may be to shape the perception of the learner or allow the learner to evaluate his performance (Kulhavy & Wager, 1993; Sales, 1993). Kluger and DeNisi (1996, p. 255) define feedback interventions as "...actions taken by (an) external agent(s) to provide information regarding some aspect(s) of one's task performance." In over one-third of the 131 studies reviewed by Kluger and DeNisi (1996), feedback actually debilitated performance. Their finding of the highly variable effect of feedback on performance is consistent with an earlier review on the topic by Balcazar, Hopkins, and Suarez (1985, p. 65) in which they concluded that "Feedback does not uniformly improve performance."

A facilitative effect on feedback may depend on the timing and content of the feedback. For timing of feedback, Book (1985) classified feedback into three categories--delayed feedback, immediate feedback, and immediate post-performance feedback. Delayed feedback occurs when feedback, such as knowledge of results of an exam, are not provided immediately following the task. When feedback is provided immediately following a behavior (e.g., responding to a question), it is known as immediate feedback. Immediate post-performance feedback is feedback that is provided once a particular task
(e.g., an assignment) is completed. Research has shown that each type of feedback can be effective depending upon the purpose the feedback is meant to serve. Delayed feedback is usually more effective for evaluation purposes while immediate feedback may be more appropriate when one seeks to adapt behaviors (e.g., in classroom and programmed instruction settings as Kulik and Kulik (1988) have found). Immediate post-performance feedback is best used when one wants learners to recall decisions that required effort and strategy use (King & Behnke, 1999). This type of feedback may be effective at improving and restructuring acquisition because the learner's focus is still on the task and his interest has not yet wavered (Johnson & Johnson, 1993).

Regarding feedback content, the most common type of feedback is known as outcome feedback, or knowledge of results. It is simply information that informs a learner as to his correctness of response (Butler & Winne, 1995). Balzer et al. (1989) defined and described another type of content feedback called cognitive feedback. Cognitive feedback contains information from which learners can link cues to achievement. There are three types of cognitive feedback--task validity feedback, cognitive validity feedback, and functional validity feedback. Task validity feedback provides information on how a cue is related to successful performance and is from an observer's perception, as opposed to that of the learner. Cognitive validity feedback provides the learner with information on the extent to which he is linking cues to performance while functional validity feedback provides information to the learner on his performance and what he estimated his performance to be.
Evidence exists that cognitive feedback is generally superior to outcome feedback across tasks, domains, and ages, and some studies (e.g., Balzer et al., 1989) have shown that task validity feedback is more effective than cognitive validity feedback for problem solving tasks. Other researchers (Bangert-Drowns et al., 1991) have found that when feedback includes elaborated information (such as in cognitive feedback), it is found to be more helpful than unelaborated outcome feedback. In addition, Andre and Thieman (1988) found that when the content of the feedback cued more active processing (such as with cognitive feedback), the feedback's effect was greater than simple outcome feedback. Based on these findings, Butler and Winne (1995) have proposed that the content of feedback should not only include domain-specific information, but also information on the strategies and tactics to help process such information.

Feedback on Adjunct Questions

Glenberg, Sanocki, Epstein, and Morris (1987) note that when feedback for adjunct questions is not provided to learners, learners cannot accurately determine how well they have learned from a reading. Therefore, Glover (1989) conducted two experiments which not only showed that learners who received feedback on adjunct questions were able to more accurately estimate their posttest performance than those who did not receive feedback, but it also showed that the level of inserted questions made a significant difference on the accuracy of their estimation. Learners were more accurate in their estimation of their performance when they received questions that required them to analyze and dissect information into associative components versus simply identifying
and recalling specific information. This study suggests that more complex inserted questions combined with feedback may help learners better regulate their learning by allowing them to more accurately measure their mastery of the material, which they can use to evaluate or modify their learning processes.

**Intended Learning Outcomes of Cognitive Feedback**

*Table 1.1* in Chapter 1 listed the intended learning outcomes for cognitive feedback. One of the intended learning outcomes was attention to a cue's relation to successful performance. Cognitive feedback contains information that links cues to successful performance and is thought to be generally superior to outcome feedback (knowledge of results only) across tasks, domains, and ages (Balzer et al., 1989). Task validity feedback is a type of cognitive feedback in which information is given by an external source on how a cue is related to successful performance and directs a learner's attention to this relationship, and by doing so, helps the learner to better monitor his subsequent task engagements (Butler & Winne, 1995). In this study, because the feedback provided was meant to direct the learner's attention to how the cues in the text were related to successfully answering the adjunct questions, it was thought that the feedback assisted the learner in better monitoring the process used to answer subsequent adjunct questions, thus reinforcing the reflective thinking prompted by the metacognitive process prompts. By focusing the learner's attention to the process he used to answer the adjunct post-questions, particularly those questions that were directed at understanding
complex processes and procedures, it was thought that his ability to understand complex procedures and processes, as measured by the Comprehension Test, would be facilitated.

Another intended learning outcome for cognitive feedback listed in Table 1.1 in Chapter 1 was comparison of one's own processing to that of an expert. When this comparison is made, a deeper understanding of one's thought processes is acquired (Lin et al., 1999). In this study, if the learner compared his own processing to that provided in the feedback, it was thought that the learner could gain a deeper understanding of his own thought processes, thereby possibly helping him to better monitor his subsequent engagements with the remaining adjunct questions. Furthermore, it was thought that the feedback might help learners acquire the more difficult concepts, principles, and procedures in the instructional content since instructional support, such as feedback, is said to be needed when the instructional content is difficult (Tobias, 1976, 1981, 1982).

**Summary**

This chapter provided an overview of cognitive information processing as the theoretical basis for the study. The information processing model reviewed consists of sequential stages in which information is processed. According to the model, information must be rehearsed in order to be maintained in working memory so that it can be encoded for storage in long-term memory for later retrieval. Semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback—the instructional strategies used in this study—were intended to facilitate the encoding of information
needed to better respond to difficult items on the dependent measures (e.g., Identification, Terminology, and Comprehension Tests), based on the item analysis conducted for this study. For each instructional strategy, a description, review of the literature, and explanation of the intended learning outcomes were examined to determine the potential efficacy of the strategies for the measured learning outcomes in this study. In the next chapter, Chapter 3, the methodology of the study is provided in addition to the results from two pilot studies.
Chapter 3

METHODOLOGY

This chapter describes the design of the study, including the materials and instrumentation used. Two pilot studies were conducted in preparation for the major study. Changes were made prior to the major study based on the results from the pilot studies. A description of each pilot study and its results are presented prior to a description of the major study.

First Pilot Study

The purpose of the first pilot study was to identify items of low achievement on each of the criterion tests (Identification Test, Terminology Test, and Comprehension Test) in order to place the instructional strategies for the major study (semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback) in the appropriate areas within the instructional script so that student performance on the criterion tests could be improved.
Subjects

Subjects were 15 volunteers at a private institute of technology in Taiwan. All subjects were Taiwanese undergraduate students majoring in English as a foreign language.

Procedures, Materials, and Instrumentation

The instructional material consisted of an instructional script on the structure and functions of the human heart (originally developed by Dwyer and Lamberski (1977) and translated into traditional Chinese). Subjects read the instructional script and were then given a set of three criterion tests to complete (Identification Test, Terminology Test, and Comprehension Test), each containing 20 multiple-choice items (originally developed by Dwyer (1978) and translated into traditional Chinese). Descriptions of the criterion tests are found in the major study of this chapter.

Results

Item analyses were conducted for each criterion test. Table 3.1 presents the results of the item analyses.
Table 3.1: Item Analysis for Each Criterion Test

<table>
<thead>
<tr>
<th>Identification Test</th>
<th>Terminology Test</th>
<th>Comprehension Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item No.</td>
<td>% Correct(^a)</td>
<td>Item No.</td>
</tr>
<tr>
<td>1</td>
<td>40</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>53</td>
<td>26</td>
</tr>
<tr>
<td>7</td>
<td>67</td>
<td>27</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>80</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>73</td>
<td>30</td>
</tr>
<tr>
<td>11</td>
<td>47</td>
<td>31</td>
</tr>
<tr>
<td>12</td>
<td>80</td>
<td>32</td>
</tr>
<tr>
<td>13</td>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>14</td>
<td>60</td>
<td>34</td>
</tr>
<tr>
<td>15</td>
<td>73</td>
<td>35</td>
</tr>
<tr>
<td>16</td>
<td>27</td>
<td>36</td>
</tr>
<tr>
<td>17</td>
<td>40</td>
<td>37</td>
</tr>
<tr>
<td>18</td>
<td>53</td>
<td>38</td>
</tr>
<tr>
<td>19</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>20</td>
<td>47</td>
<td>40</td>
</tr>
</tbody>
</table>

\(^a\)Percentage of subjects who correctly answered the Identification Test item.

\(^b\)Percentage of subjects who correctly answered the Terminology Test item.

\(^c\)Percentage of subjects who correctly answered the Comprehension Test item.
Percentages were also calculated for each of the incorrect responses for each item on all three criterion tests because "not only is it important to know that...half the learners missed a particular item, but it is just as important to know that most of those who missed the item picked the same distractor in a multiple-choice item..." (Dick & Carey, 1996, p. 297). Therefore, when at least one of the percentages of an incorrect response was greater than or equal to the percentage of subjects who correctly answered the test item (meaning that either more or the same number of subjects selected the same incorrect response than the number of subjects who selected the correct response), then the test item was judged to be difficult and targeted as an item that had the greatest potential to be enhanced by the instructional strategies in the major study.

Using the procedure described above, a total of 27 out of the 60 test items were judged to be difficult. However, because it was found that the areas within the instructional script that would require enhancement would not only affect the 27 items, but 9 additional items as well, a total of 36 out of the 60 test items were found to have the potential to be improved through the insertion of the instructional strategies in the major study. For the Identification Test, a total of 9 items (items 2, 4, 5, 6, 8, 11, 13, 16, and 19) had the potential for improvement. The Terminology Test had 12 items (items 21, 22, 25, 26, 29, 33, 34, 36, 37, 38, 39, and 40) with the potential for improvement. For the Comprehension Test, 15 items (items 42, 43, 44, 45, 46, 49, 50, 51, 52, 55, 56, 57, 58, 59, and 60) had the potential for improvement. Except for one of the 36 items, all items had a percent correct of 60 or below.
Second Pilot Study

The purpose of the second pilot study was to examine the treatment design and instrumentation prior to its implementation in the major study.

Subjects

Subjects were 87 volunteers at a private institute of technology in Taiwan. All subjects were Taiwanese undergraduate students majoring in either English as a foreign language or management and information science.

Materials

The instructional material was created in Microsoft PowerPoint 97 and consisted of an instructional script on the structure and functions of the human heart (originally developed by Dwyer and Lamberski (1977) and translated into traditional Chinese). The various semantic map treatments to be used in the major study were positioned in the instructional script for each of the four treatment groups. Semantic map treatments consisted of only semantic maps or varied combinations of semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback. Placement of each treatment was based on the results from the first pilot study and was intended to reinforce the corresponding verbal information in the instructional script.
Instructional Treatments

Different combinations of instructional strategies made up the four different semantic map treatments used in the second pilot study.

Treatment 1

Subjects in Treatment 1 viewed the heart instruction with embedded semantic maps. Each screen of the computer instruction was sequenced such that subjects first read a passage of the instructional script and then viewed a semantic map of the passage. 

*Figure 3.1* provides a sample of a semantic map embedded in the instructional script for Treatment 1.
Treatment 2

Subjects in Treatment 2 viewed the heart instruction with embedded semantic maps. However, unlike Treatment 1, one adjunct question followed every semantic map. Each adjunct question was presented on a separate PowerPoint slide. Subjects were asked to write their response to each adjunct question on an answer sheet. The adjunct questions required subjects to review information in the semantic maps in addition to relevant information in the corresponding text passage. Figure 3.2 provides a sample of an adjunct question in the instructional script. The adjunct question corresponds to the semantic map in Figure 3.1.
Treatment 3

Subjects in Treatment 3 viewed the heart instruction with embedded semantic maps. Like Treatment 2, one adjunct question followed every semantic map. In addition, after subjects responded to an adjunct question, they were presented, on the same PowerPoint slide, with a metacognitive process prompt that also requested a written response. The metacognitive process prompt focused subjects' attention on how they came to their response to the adjunct question. Figure 3.3 provides a sample of a metacognitive process prompt.
Treatment 4

Like subjects in Treatment 3, subjects in Treatment 4 viewed the heart instruction with embedded semantic maps followed by adjunct questions and metacognitive process prompts. However, this group also received cognitive feedback which followed the metacognitive process prompts. *Figure 3.4* provides an example of cognitive feedback.
One way you could have determined the answer for Q7 is by first examining the question itself. This can give you an indication of how you can proceed to find the answer. Since Q7 asks for how the location and the characteristics of the valve allow it to function, this indicates that both are required for it to function and that maybe there’s a relationship between the two that makes the valve work. Looking at the ‘Tricuspid Valve’ semantic map, you see that there’s a node labeled ‘Location’ that tells you that the valve is located between the right auricle and the right ventricle. There’s also a node labeled ‘Characteristics’ that tells you that the valve is strong and fibrous and has three triangular flaps. Taken together, this information tells us that there are three flaps between the right auricle and right ventricle that somehow allow the valve to do its job. But you may have asked yourself what that job is. Again, looking at the semantic map, there’s a node labeled ‘Functions’ that tells you that the tricuspid valve permits blood flow to the right ventricle and prevents blood flow to the right auricle. You may have asked yourself how this information is related to what you already know about the tricuspid valve--that it consists of three flaps located between the right auricle and the right ventricle. You may have come to the conclusion that because of this, the flaps must be open to allow blood to flow into the right ventricle but closes up to prevent blood from flowing back into the right auricle.

Figure 3.4: Sample Cognitive Feedback for Treatment 4

**Instrumentation**

Achievement of each learning outcome by subjects in each treatment group were obtained from three print-based criterion tests--the Identification Test, the Terminology Test, and the Comprehension Test--each containing 20 multiple-choice items (originally developed by Dwyer (1978) and translated into traditional Chinese). The criterion tests are described later in this chapter in the Instrumentation section of the major study.
Procedures

Data collection took place over two days in two two-hour sessions. Random assignment of subjects to treatment groups was done by sequentially loading treatments on each computer (e.g., Treatment 1, 2, 3, 4, 1, 2, 3, 4, etc.) in one of the institute's computer learning labs and then allowing subjects to seat themselves at one of the computers upon entering the computer lab. Upon completing the self-paced instructional module, subjects were given all three criterion tests to complete. If a subject had an answer sheet that was used to respond to the adjunct post-questions and metacognitive process prompts, it was collected before criterion tests were distributed to him or her.

Results

Kuder-Richardson 20 (K-R 20) reliability coefficients were calculated for the criterion tests (Identification Test, Terminology Test, and Comprehension Test). Table 3.2 presents the reliability coefficient for each criterion test.
Mean scores and standard deviations on the criterion tests for each treatment group are presented in Table 3.3. Group means were very similar on each of the criterion tests with means on the Identification Test practically the same.

Table 3.3: Mean Scores and Standard Deviations on Criterion Tests For All Treatment Groups

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 1</td>
<td>23 7.43 3.03</td>
<td>24 8.57 2.56</td>
<td>21 7.00 2.68</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>24 7.42 3.39</td>
<td>24 8.13 3.05</td>
<td>21 7.17 2.65</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>21 7.52 3.19</td>
<td>21 7.67 2.70</td>
<td>21 5.67 2.46</td>
</tr>
<tr>
<td>Treatment 4</td>
<td>19 7.37 2.94</td>
<td>19 6.32 1.89</td>
<td>19 6.47 1.78</td>
</tr>
<tr>
<td>Total</td>
<td>87 7.44 3.10</td>
<td>87 7.74 2.70</td>
<td>87 6.61 2.47</td>
</tr>
</tbody>
</table>

Note. Maximum score possible = 20.00

One-way analysis of variance (ANOVA) was used to analyze the data collected in the second pilot study. Alpha was set at the .05 significance level. Table 3.4 presents the results of the one-way analysis of variance for each of the criterion tests.
Results revealed that no significant differences existed between treatment groups on each of the criterion tests. Because the results of the second pilot study showed no significant differences, revisions were made to the design of the major study.

### Major Study

The purpose of the major study was to examine the effects of adjunct postquestions, metacognitive process prompts, and cognitive feedback in complementing semantic maps embedded within an expository text passage on the immediate and subsequent achievement of three types of learning outcomes: 1) knowledge of specific facts, terms, and definitions; 2) ability to identify parts or positions of an object; and 3) understanding of complex procedures and processes, when training on semantic maps and metacognitive process prompts is not provided to learners and when it is provided to learners. The remainder of Chapter 3 is devoted to describing the major study.

In the second pilot study, except for a brief introduction to semantic maps at the beginning of the instructional materials, all four treatment groups did not receive any

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>3</td>
<td>.01</td>
<td>2.52</td>
<td>1.67</td>
</tr>
<tr>
<td>Error</td>
<td>83</td>
<td>(9.94)</td>
<td>(6.33)</td>
<td>(5.99)</td>
</tr>
</tbody>
</table>

*Note. Values enclosed in parentheses represent mean square errors.*
training on any of the semantic map treatments. However, because this population of students tend not to be familiar with semantic maps and metacognitive process prompts, training was provided to half of the treatment groups in the major study. Therefore, in the major study, each of the four treatment groups was divided into two subgroups--those who did not receive training on semantic maps and, if applicable, metacognitive process prompts (Group A) and those who did receive training on semantic maps and, if applicable, metacognitive process prompts (Group B). Thus, the study consisted of a total of eight treatment groups--Treatments 1 through 4 in Group A and Treatments 1 through 4 in Group B.

In addition, while the second pilot study measured subjects' immediate achievement of the three learning outcomes, the major study examined both the immediate and delayed achievement of the three learning outcomes. Since no significant differences in immediate achievement were found in the second pilot study, it was thought beneficial to repeat the administration of the dependent measures to determine if significant treatment effects are only observable when testing is delayed. The two hypotheses offered for the major study were:

\[
H_0: \text{There will be insignificant differences in the immediate and in the delayed achievement of different learning outcomes across the varied semantic map treatments when training on strategies (semantic maps and metacognitive process prompts) is and is not provided to learners. The different learning outcomes were defined as a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an}
\]
object; and c. understanding of complex procedures and processes, while the varied semantic map treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

H1: Within each of the four semantic map treatments, there will be significant differences between the immediate and delayed achievement of different learning outcomes when training on strategies (semantic maps and metacognitive prompts) is and is not provided to learners. The different learning outcomes were defined as a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an object; and c. understanding of complex procedures and processes, while the varied semantic map treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

Subjects

The subject pool consisted of 288 volunteers at a private institute of technology in Taiwan. All subjects were Taiwanese undergraduate students majoring in English as a foreign language. Subjects were not compensated for their participation, nor was the instructional content used in the study related to their coursework, so subjects may have
lacked the interest and motivation to fully participate in this study. However, since the instructional content described the structure and function of the human heart, it may have been of interest to some of the participants.

**Materials**

The instructional material used in the major study was created in Microsoft PowerPoint 97 and consisted of an instructional script on the structure and functions of the human heart (originally developed by Dwyer and Lamberski (1977) and translated into traditional Chinese). The four semantic map treatments, meant to complement the instructional script's verbal information, consisted of only semantic maps or varied combinations of semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback. Placement of each treatment was based on the item analysis results from the first pilot study and, therefore, did not deviate from that of the second pilot study. A Chinese medical doctor validated the content of the 2,658-word instructional script, and a certified professional translator of traditional Chinese verified the accuracy of the translation by comparing the Chinese script to the English script.

**Instructional Treatments**

In the study, different combinations of instructional strategies made up the four semantic map treatments--Treatments 1, 2, 3, and 4--in Groups A and B.
Group A

Before completing the instructional modules on the human heart, subjects in Group A did not receive training on any of the instructional strategies used in Treatments 1 through 4. However, all subjects in Group A did receive a brief introduction to semantic maps at the beginning of the instructional modules. The introduction presented an example of a semantic map with a short description of its structure. The same introduction and semantic map example were used for all four treatment groups (Treatments 1, 2, 3, and 4) in Group A. The English version of the semantic map introduction can be found in Appendix A, and the traditional Chinese version can be found in Appendix B. Subjects in Group A were assigned to one of the following four treatments.

Treatment 1

Subjects in Treatment 1 viewed the heart instruction with embedded semantic maps. Each screen of the computer instruction was sequenced such that subjects first read a passage of the instructional script and then viewed a semantic map of the passage. The form of the semantic maps was modeled after the semantic map examples of Jonassen et al. (1993, pp. 136-139) and Roshan (1997, p. 63). The complete treatment can be viewed in Appendix C (English version) and Appendix D (Chinese version).
Treatment 2

Subjects in Treatment 2 also viewed the heart instruction with embedded semantic maps. However, unlike Treatment 1, one adjunct question followed every semantic map. The adjunct questions were intended to make subjects review information in the semantic maps in addition to relevant information in the corresponding text passage. Subjects were asked to write their response to each adjunct question on an answer sheet. The complete treatment can be viewed in Appendix E (English version) and Appendix F (Chinese version).

Treatment 3

Subjects in Treatment 3 viewed the heart instruction with embedded semantic maps. Like Treatment 2, one adjunct question followed every semantic map. In addition, once subjects responded to each adjunct question, they were presented with a metacognitive process prompt that also requested a written response. The metacognitive process prompt was meant to focus subjects' attention on how they came to their response to the adjunct question. The metacognitive process prompts were modeled after the examples provided by Lin et al. (1999, pp. 49-50). The complete treatment can be viewed in Appendix G (English version) and Appendix H (Chinese version).
Treatment 4

Like subjects in Treatment 3, subjects in Treatment 4 viewed the heart instruction with embedded semantic maps followed by adjunct questions and metacognitive process prompts. In addition, subjects in Treatment 4 also received cognitive feedback which followed the metacognitive process prompts. The cognitive feedback was meant to model responses to the metacognitive process prompts and to focus subjects' attention on the process such that they see how the other instructional strategies, particularly the semantic maps and the adjunct questions, can reinforce their learning of the material (Butler & Winne, 1995, p. 251; Lin et al., 1999, p. 50). Unlike the second pilot study, in the major study, the semantic maps were viewable alongside the cognitive feedback so that subjects could refer to the semantic maps as the cognitive feedback made reference to them and their parts. The complete treatment can be viewed in Appendix I (English version) and Appendix J (Chinese version).

Group B

Subjects in Group B received a brief introduction to semantic maps at the beginning of the instructional modules. As with Group A, the introduction presented an example of a semantic map with a short description of its structure. The same introduction and semantic map example were used for all four treatment groups (Treatments 1, 2, 3, and 4) in Group B. The English version of the semantic map
introduction can be found in Appendix A, and the traditional Chinese version can be found in Appendix B.

In addition to the semantic map introduction, subjects in Group B also received training on how to interpret semantic maps and, if applicable, metacognitive process prompts. A total of six one-hour training sessions--three on semantic maps and three on metacognitive process prompts--were administered during the first week of the study to subjects in Group B. Those in Treatments 1 through 4 received one-hour researcher-led training sessions on semantic maps that introduced subjects to the structure of semantic maps and their relation to accompanying text. Subjects in Treatments 3 and 4 received an additional hour of training on how to respond to metacognitive process prompts. All training sessions used subjects' current course content. Thus, the training with the subjects from the English as a foreign language (EFL) program was conducted in both English and Chinese, with the researcher leading the training in English and an English faculty member providing Chinese translation.

About a third of the subjects in Treatments 1 through 4 in Group B were enrolled in a multimedia course offered through the EFL program. At the time of the study, subjects in this course were learning how to produce a resume in PowerPoint. Therefore, the semantic maps used to train subjects in this group were related to resume development. Subjects were given instruction on resume writing and were shown examples of semantic maps that displayed information on resume writing. For each example, the researcher identified the parts of the semantic maps--the main idea, categories, and concepts related to each category--with the hope of increasing subjects'
familiarity with and improving subjects' interpretation and understanding of semantic maps. *Figure 3.5* provides a sample semantic map used to train subjects in this group.

*Figure 3.5: Sample Semantic Map for Semantic Map Training for Subjects in Treatments 1 through 4 Enrolled in the Multimedia Course*

An hour of training on metacognitive process prompts was provided to subjects in Treatments 3 and 4 in the multimedia course. The subjects were given a two-page introduction on metacognitive process prompts to read. The two-page introduction, written in both English and Chinese, can be found in Appendix K. Once subjects read the introduction, subjects were shown examples of semantic maps on resume writing, and, in addition to the examples, subjects were shown adjunct questions that corresponded to the
semantic maps. Subjects were also shown the appropriate responses to the adjunct questions. The metacognitive process prompts that corresponded to the adjunct questions were also shown to subjects, along with possible responses to the metacognitive process prompts. English and Chinese verbal explanations were provided throughout the presentation of the examples, and subjects were continually asked whether they understood what was being conveyed to them; questions were also encouraged. Figure 3.6 provides a sample semantic map used in the metacognitive process prompt training, Figure 3.7 provides a sample adjunct question used in the metacognitive process prompt training, Figure 3.8 provides a sample response to the adjunct question in Figure 3.7, Figure 3.9 provides a sample metacognitive process prompt used in the training, Figure 3.10 provides a sample response to the metacognitive process prompt in Figure 3.9.

Figure 3.6: Sample Semantic Map for Metacognitive Process Prompt Training for Subjects in Treatments 3 and 4 Enrolled in the Multimedia Course
Q1: What is the relationship between Craig Simpson's job objective and his previous job experience?

*Figure 3.7: Sample Adjunct Question for Metacognitive Process Prompt Training for Subjects in Treatments 3 and 4 Enrolled in the Multimedia Course*

His job experience is tailored to his job objective. For example, his experience of being a retail sales specialist, selling products and services, and delivering sales presentations and demos are tailored to his objective of obtaining a position as a sales representative while his experience of working for ABC Telecommunications, Inc., evaluating wireless telecom needs, and recommending wireless telecom products and services is tailored to his objective of working in the wireless telecommunications industry.

*Figure 3.8: Sample Response to the Adjunct Question in Figure 3.7*

Q2: How did you arrive at an answer to Q1?

*Figure 3.9: Sample Metacognitive Process Prompt for Metacognitive Process Prompt Training for Subjects in Treatments 3 and 4 Enrolled in the Multimedia Course*
Because Q1 asks about the relationship between job objective and job experience, I looked at only those two categories in the semantic map. Then I compared the concepts under each category and found that some things listed under experience were directly related to or matched the objective of being a sales representative while other things listed under experience were related to the industry--wireless communications--that Craig Simpson wants to work in.

Figure 3.10: Sample Response to the Metacognitive Process Prompt in Figure 3.9

Another third of the subjects in Treatments 1 through 4 in Group B were enrolled in a course on the internet offered through the EFL program. At the time of the study, subjects in this course were learning about information on films that were accessible through the World Wide Web. Therefore, the semantic maps used to train subjects in this group were related to a popular film in Taiwan titled, "Crouching Tiger, Hidden Dragon." Subjects were asked to read information on the film obtained from a web site and were then shown examples of semantic maps that displayed selected information from the web site. For each example, the researcher identified the parts of the semantic maps--the main idea, categories, and concepts related to each category--with the hope of increasing subjects' familiarity with and improving subjects' interpretation and understanding of semantic maps. Figure 3.11 provides a sample semantic map used to train subjects in this group.
An hour of training on metacognitive process prompts was provided to subjects in Treatments 3 and 4 in the internet course. The subjects were given a two-page introduction on metacognitive process prompts to read. The two-page introduction, written in both English and Chinese, can be found in Appendix K. After subjects read the introduction, subjects were shown examples of semantic maps that displayed information on the popular film titled "Crouching Tiger, Hidden Dragon," and in addition to the examples, subjects were shown adjunct questions that corresponded to the semantic maps. Subjects were also shown the appropriate responses to the adjunct questions. The metacognitive process prompts that corresponded to the adjunct questions were also
shown to subjects, along with possible responses to the metacognitive process prompts. English and Chinese verbal explanations were provided throughout the presentation of the examples, and subjects were continually asked whether they understood what was being conveyed to them; questions were also encouraged. Figure 3.12 provides a sample semantic map used in the metacognitive process prompt training, Figure 3.13 provides a sample adjunct question used in the metacognitive process prompt training, Figure 3.14 provides a sample response to the adjunct question in Figure 3.13, Figure 3.15 provides a sample metacognitive process prompt used in the training, Figure 3.16 provides a sample response to the metacognitive process prompt in Figure 3.15.

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**Figure 3.12**: Sample Semantic Map for Metacognitive Process Prompt Training for Subjects Treatment 3 and 4 Enrolled in the Internet Course

---

**Q1**: How are the purposes for burning incense related to when or where the incense is burned?

---

**Figure 3.13**: Sample Adjunct Question for Metacognitive Process Prompt Training for Subjects in Treatments 3 and 4 Enrolled in the Internet Course

---
The reasons for burning incense depend on when the incense is burned and where the incense is burned. For example, incense is burned for good luck (including good weather) in the Hong Kong movie industry before film scenes that involve risk. However, in the China desert, incense is burned to get rain.

Figure 3.14: Sample Response to the Adjunct Question in Figure 3.13

Q2: How did you determine what the answer is for Q1?

Figure 3.15: Sample Metacognitive Process Prompt for Metacognitive Process Prompt Training for Subjects in Treatments 3 and 4 Enrolled in the Internet Course

Because the question (Q1) asks about the relationship between the purpose of burning incense and the time and place that the practice occurs, I focused on these categories in the semantic map. However, the semantic map didn't tell me which purpose or reason corresponds to which concept under "When/Where." Therefore, I needed to review the paragraph to find out which purpose corresponds to which time and location.

Figure 3.16: Sample Response to the Metacognitive Process Prompt in Figure 3.15

A final third of the subjects in Treatments 1 through 4 in Group B were enrolled in a course on research methods offered through the EFL program. At the time of the study, subjects in this course were examining a study on Taiwanese aboriginals' English learning. Therefore, the semantic maps used to train subjects in this group were related to information found in study. Subjects were asked to review selected sections from the
study and were then shown examples of semantic maps that displayed information from those sections. For each example, the researcher identified the parts of the semantic maps—the main idea, categories, and concepts related to each category—with the hope of increasing subjects’ familiarity with and improving subjects’ interpretation and understanding of semantic maps. Figure 3.17 provides a sample semantic map used to train subjects in this group.

![Sample Semantic Map for Semantic Map Training for Subjects in Treatments 1 through 4 Enrolled in the Research Methods Course](image)

*Figure 3.17: Sample Semantic Map for Semantic Map Training for Subjects in Treatments 1 through 4 Enrolled in the Research Methods Course*

An hour of training on metacognitive process prompts was provided to subjects in Treatments 3 and 4 in the research methods course. The subjects were given a two-page introduction on metacognitive process prompts to read. The two-page introduction, written in both English and Chinese, can be found in Appendix K. Once subjects read the introduction, subjects were shown examples of semantic maps that displayed information from a study on Taiwanese aboriginals’ English learning, and in addition to the examples, subjects were shown adjunct questions that corresponded to the semantic maps. Subjects
were also shown the appropriate responses to the adjunct questions. The metacognitive process prompts that corresponded to the adjunct questions were also shown to subjects, along with possible responses to the metacognitive process prompts. English and Chinese verbal explanations were provided throughout the presentation of the examples, and subjects were continually asked whether they understood what was being conveyed to them; questions were also encouraged. *Figure 3.18* provides a sample semantic map used in the metacognitive process prompt training, *Figure 3.19* provides a sample adjunct question used in the metacognitive process prompt training, *Figure 3.20* provides a sample response to the adjunct question in *Figure 3.19,* *Figure 3.21* provides a sample metacognitive process prompt used in the training, *Figure 3.22* provides a sample response to the metacognitive process prompt in *Figure 3.21.*

---

*Figure 3.18: Sample Semantic Map for Metacognitive Process Prompt Training for Subjects Treatment 3 and 4 Enrolled in the Research Methods Course*
Q1: How are the findings from the classroom observations related to the findings from the interview with the director?

*Figure 3.19: Sample Adjunct Question for Metacognitive Process Prompt Training for Subjects in Treatments 3 and 4 Enrolled in the Research Methods Course*

The findings from the classroom observations and those from the interview with the director of the school corroborate each other. The director commented that it's difficult for students to keep in their seats and keep quiet, and the classroom observations showed that students' behaviors are accurately described by the director.

*Figure 3.20: Sample Response to the Adjunct Question in Figure 3.19*

Q2: How did you find your answer to Q1?

*Figure 3.21: Sample Metacognitive Process Prompt for Metacognitive Process Prompt Training for Subjects in Treatments 3 and 4 Enrolled in the Research Methods Course*
Like subjects in Group A, subjects in Group B were assigned to one of the following four treatments. Unlike subjects in Group A, subjects in Treatments 1 and 2 in Group B received training on semantic maps, and subjects in Treatments 3 and 4 in Group B received training on semantic maps and metacognitive process prompts.

Treatment 1

Subjects in Treatment 1 viewed the heart instruction with embedded semantic maps. These subjects had already received training a week prior on interpreting semantic maps. Each screen of the computer instruction was sequenced such that subjects first read a passage of the instructional script and then viewed a semantic map of the passage. The form of the semantic maps was modeled after the semantic map examples of Jonassen et al. (1993, pp. 136-139) and Roshan (1997, p. 63). The complete treatment can be viewed in Appendix C (English version) and Appendix D (Chinese version).
Treatment 2

Subjects in Treatment 2 also viewed the heart instruction with embedded semantic maps. These subjects had already received training a week prior on interpreting semantic maps. Unlike Treatment 1, one adjunct question followed every semantic map in Treatment 2. The adjunct questions were intended to make subjects review information in the semantic maps in addition to relevant information in the corresponding text passage. Subjects were asked to write their response to each adjunct question on an answer sheet. The complete treatment can be viewed in Appendix E (English version) and Appendix F (Chinese version).

Treatment 3

Subjects in Treatment 3 viewed the heart instruction with embedded semantic maps. Like Treatment 2, one adjunct question followed every semantic map. In addition, once subjects responded to each adjunct question, they were presented with a metacognitive process prompt that also requested a written response. The metacognitive process prompt was meant to focus subjects' attention on how they came to their response to the adjunct question. The metacognitive process prompts were modeled after the examples provided by Lin et al. (1999, pp. 49-50). These subjects had already received training a week prior on interpreting semantic maps and metacognitive process prompts. The complete treatment can be viewed in Appendix G (English version) and Appendix H (Chinese version).
Treatment 4

Like subjects in Treatment 3, subjects in Treatment 4 viewed the heart instruction with embedded semantic maps followed by adjunct questions and metacognitive process prompts. These subjects had already received training a week prior on interpreting semantic maps and metacognitive process prompts. In addition, subjects in Treatment 4 also received cognitive feedback which followed the metacognitive process prompts in their instructional module. The cognitive feedback was meant to model responses to the metacognitive process prompts and to focus subjects’ attention on the process such that they see how the other instructional strategies, particularly the semantic maps and the adjunct questions, can reinforce their learning of the material (Butler & Winne, 1995, p. 251; Lin et al., 1999, p. 50). Unlike the second pilot study, in the major study, improvements were made to the cognitive feedback by providing the semantic maps for subjects to view as the cognitive feedback made reference to them. The complete treatment can be viewed in Appendix I (English version) and Appendix J (Chinese version).

Instrumentation

Achievement scores of each learning outcome by subjects in each treatment group was obtained from three print-based criterion tests--the Identification Test, the Terminology Test, and the Comprehension Test--each containing 20 multiple-choice items (originally developed by Dwyer (1978) and translated into traditional Chinese). The
translation of all three criterion tests was verified by a professional translator of traditional Chinese. In the Identification Test, subjects selected the correct name of the heart structure that corresponded to the part of the heart highlighted by an arrow pointing to it. The Identification Test was meant to examine students' ability to identify parts or positions of an object through the use of visual cues to discriminate among the parts. In the Terminology Test, subjects selected the correct part or function of the heart described in each item. The Terminology Test was meant to measure students' knowledge of specific facts, terms, and definitions found in the verbal instruction. In the Comprehension Test, subjects selected the correct response to items focused on complex processes and procedures of the human heart. The Comprehension Test was meant to not only measure students' understanding of complex processes and procedures, but the test was also designed to determine comprehension of the verbal instruction such that the students are able to explain some other event or occurrence within the functioning of the human heart. All three tests were combined into one 60-item test with the first 20 items (items 1 through 20) belonging to the Identification Test, the second 20 items (items 21 through 40) belonging to the Terminology Test, and the last 20 items (items 41 through 60) belonging to the Comprehension Test. The complete set of criterion tests can be found in Appendix L (English version) and Appendix M (Chinese version).

**Procedures**

The study employed a 4 x 2 factorial design—four different semantic map treatments (Treatment 1, Treatment 2, Treatment 3, and Treatment 4) and two levels of
the moderator variable—(1) no training on semantic maps and metacognitive process prompts (Group A) and (2) training on semantic maps and, if applicable, metacognitive process prompts (Group B). Upon completion of the instructional materials, all eight treatment groups were post-tested twice (immediately and one week later) on the three dependent variables—achievement of knowledge of specific facts, terms, and definitions; achievement of the ability to identify parts or positions of an object; and achievement of understanding of complex procedures and processes--using the corresponding criterion tests--the Identification Test, the Terminology Test, and the Comprehension Test. Table 3.5 presents a schematic of the design of the study.

Table 3.5: Schematic of the Design of the Study

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Immediate Observation</th>
<th>One-week Delayed Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>X₁</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Training</td>
<td>O₁</td>
<td>O₂</td>
</tr>
<tr>
<td>Training</td>
<td>O₃</td>
<td>O₄</td>
</tr>
<tr>
<td>X₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Training</td>
<td>O₅</td>
<td>O₆</td>
</tr>
<tr>
<td>Training</td>
<td>O₇</td>
<td>O₈</td>
</tr>
<tr>
<td>X₃</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Training</td>
<td>O₉</td>
<td>O₁₀</td>
</tr>
<tr>
<td>Training</td>
<td>O₁₁</td>
<td>O₁₂</td>
</tr>
<tr>
<td>X₄</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Training</td>
<td>O₁₃</td>
<td>O₁₄</td>
</tr>
<tr>
<td>Training</td>
<td>O₁₅</td>
<td>O₁₆</td>
</tr>
</tbody>
</table>
At the beginning of the study, subjects were randomly assigned to one of the eight treatment groups. During the first week of the study, subjects in Treatments 1 through 4 in Group B received a one-hour researcher-led training on semantic maps that introduced subjects to the structure of semantic maps and their relation to accompanying text. Furthermore, subjects in Treatments 3 and 4 in Group B received an additional hour of training on how to respond to metacognitive process prompts. As part of the design of the major study, subjects in Treatments 1 through 4 in Group A were not given training on any of the semantic map treatments.

During the second week of the study, subjects viewed the self-paced instructional module on the structure and function of the human heart; for subjects in Group B, this took place one week after having received training on semantic maps and, if applicable, metacognitive process prompts. Subjects in Treatments 2, 3, and 4 in both Group A and Group B were given response sheets upon which to write their answers to the adjunct questions and, if applicable, metacognitive process prompts. Upon completion of the heart instruction, response sheets were collected, and subjects were given all three criterion tests (Identification Test, Terminology Test, and Comprehension Test) to complete.

During the third week of the study, which was one week after completing the heart instruction and initial testing, subjects were tested again using all three criterion tests. The purpose of this second testing period was to examine the amount of information retained since the first testing period. Table 3.6 presents a summary of the implementation process for the final study. An "X" indicates receipt of an item.
Table 3.6: Summary of the Implementation Process for the Final Study

<table>
<thead>
<tr>
<th>Week</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Treatment</td>
</tr>
<tr>
<td>One</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semantic map training (one hour)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Metacognitive process prompt training (one hour)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Two</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer instruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With 13 Semantic maps</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>With 13 Adjunct post-questions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>With 13 Metacognitive process prompts</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>With 13 Cognitive feedback provisions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Immediate testing (upon completion of instruction)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification Test (20 items)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Terminology Test (20 items)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Comprehension Test (20 items)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Three</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delayed testing (one week after immediate testing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification Test (20 items)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Terminology Test (20 items)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Comprehension Test (20 items)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Data Analysis

The SPSS (Statistical Package for the Social Sciences) version 9.0 statistical package was used to conduct all statistical analyses. The following describe the data analysis procedures for each of the two hypotheses.

For the analysis of Hypothesis 1, an assessment of the correlations among the dependent variables was conducted to determine how to proceed with the quantitative analysis. According to Tabachnick and Fidell (1996, p. 376), when dependent variables are correlated, multiple testing using analysis of variance (ANOVA) increases the probability of committing a Type 1 error. Therefore, to better control for false positives, multivariate analysis of variance (MANOVA) should be used when dependent variables are at least moderately correlated (Stevens, 1999, p. 110). For this study, Davis's (1971, p. 49) interpretation of a moderate correlation as ±0.30 to 0.49 was used to determine if a two-way MANOVA was to be used or if a two-way ANOVA individually conducted with each dependent variable was to be used. Because the dependent variables were shown to be at least moderately correlated, a two-way MANOVA was used. The results of the MANOVA are presented in Chapter 4.

For the quantitative analysis of Hypothesis 2, a doubly repeated measures multivariate analysis of variance (MANOVA) with three dependent variables and time as the within-factor variable was used once it was found that all required assumptions were met (Tabachnick & Fidell, 2001b, pp. 423-429). The three dependent measures were the Identification Test, Terminology Test, and Comprehension Test scores. The within-factor variable, time, had two levels--immediate and delayed testing periods. Because
significant results were obtained through the doubly repeated measures MANOVA, to identify within which dependent measure significant differences existed between testing periods, post hoc tests were used. In order to determine which post hoc tests to use, the assumption of sphericity was examined. SPSS uses the Mauchly test of sphericity to test the assumption of sphericity, which, if violated, inflates the F value (Tabachnick & Fidell, 2001a, p. 289). In this study, because the Mauchly test was nonsignificant, sphericity could not be assumed, so the more liberal Huynh-Feldt test was selected over the more conservative Greenhouse-Geisser test to identify the dependent measure(s) containing significant differences (Tabachnick & Fidell, 2001a, pp. 291-292). One-sample t tests were performed to further identify where the differences existed. Statistical significance for the one-sample t test was set at .025. The one-sample t test examined whether or not a test score difference value was significantly different from zero (0). A test score difference that was not found to be significantly different from a value of 0 indicated that the test score achieved in the first testing period was not significantly different from that achieved in the second testing period or that the difference was due to chance. The results of the doubly repeated measures MANOVA, the Huynh-Feldt tests, and the one-sample t tests are presented in Chapter 4.
Chapter 4

RESULTS

This chapter reports the results for the quantitative analyses of the study. The analysis for each of the study's two hypotheses are reported separately following the presentation of the criterion test reliabilities and descriptive statistics. The SPSS (Statistical Package for the Social Sciences) version 9.0 statistical package was used to conduct all statistical analyses.

The test reliabilities, descriptive statistics, and statistical analyses for each of the hypotheses were based on the data obtained from 270 subjects. Data were originally obtained from 288 participants; however, in 18 out of the 288 cases, more than 20 percent of the test items were missing data on one or more of the criterion tests. Therefore, these 18 cases were eliminated from the analysis of the study. For 13 out of the 288 cases in which data was missing from 20 percent or less of the criterion test items, a value of zero (0) was assigned to those items and the cases were included in the analysis of the data, based on advice from the director of the National Center for Educational Statistics (S. Peng, personal communication, April 12, 2001).
Test Reliabilities

Table 4.1 presents the Kuder-Richardson 20 (K-R 20) reliability coefficients calculated for each of the criterion measures reported by strategy training for both immediate and delayed testing.

Table 4.1: K-R 20 Reliability Coefficients for Criterion Tests by Strategy Training and Testing Period

<table>
<thead>
<tr>
<th>Strategy Training and Testing Period</th>
<th>Criterion Test Component</th>
<th>Identification Test</th>
<th>Terminology Test</th>
<th>Comprehension Test</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>None Received&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>148</td>
<td>.65</td>
<td>.52</td>
<td>.37</td>
<td>.75</td>
</tr>
<tr>
<td>Delayed</td>
<td>148</td>
<td>.65</td>
<td>.60</td>
<td>.25</td>
<td>.79</td>
</tr>
<tr>
<td>Received&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>122</td>
<td>.68</td>
<td>.66</td>
<td>.42</td>
<td>.80</td>
</tr>
<tr>
<td>Delayed</td>
<td>122</td>
<td>.68</td>
<td>.63</td>
<td>.39</td>
<td>.80</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>270</td>
<td>.67</td>
<td>.60</td>
<td>.39</td>
<td>.77</td>
</tr>
<tr>
<td>Delayed</td>
<td>270</td>
<td>.66</td>
<td>.62</td>
<td>.32</td>
<td>.76</td>
</tr>
</tbody>
</table>

<sup>a</sup>No pre-instruction training provided to participants on any of the strategies found in the instruction.

<sup>b</sup>Pre-instruction training provided to participants on understanding the structure and function of selected strategies found in the instruction.

While the reliability coefficients were not as high as desired, overall, general consistency was shown among the coefficients across the testing periods. Further discussion of the reliability coefficients is found in Chapter 5.
Descriptive Statistics

Mean scores and standard deviations on the criterion tests for each treatment group are presented in this section. The mean scores and standard deviations achieved during immediate testing are presented in *Table 4.2* while those achieved during delayed testing are presented in *Table 4.3*.
Table 4.2: Mean Scores and Standard Deviations on Criterion Tests For All Treatment Groups - Immediate Testing

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>n</th>
<th>Identification M</th>
<th>Identification SD</th>
<th>Terminology M</th>
<th>Terminology SD</th>
<th>Comprehension M</th>
<th>Comprehension SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None Received</td>
<td>148</td>
<td>7.41</td>
<td>3.36</td>
<td>7.62</td>
<td>2.86</td>
<td>6.24</td>
<td>2.48</td>
</tr>
<tr>
<td>Received</td>
<td>122</td>
<td>7.44</td>
<td>3.47</td>
<td>7.52</td>
<td>3.36</td>
<td>6.25</td>
<td>2.59</td>
</tr>
<tr>
<td>Strategy Used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategy 1(^{a})</td>
<td>69</td>
<td>7.78</td>
<td>3.27</td>
<td>7.38</td>
<td>3.10</td>
<td>5.77</td>
<td>2.51</td>
</tr>
<tr>
<td>Strategy 2(^{b})</td>
<td>67</td>
<td>7.69</td>
<td>3.65</td>
<td>8.06</td>
<td>2.76</td>
<td>6.75</td>
<td>2.29</td>
</tr>
<tr>
<td>Strategy 3(^{c})</td>
<td>70</td>
<td>7.27</td>
<td>3.47</td>
<td>7.47</td>
<td>3.29</td>
<td>6.03</td>
<td>2.76</td>
</tr>
<tr>
<td>Strategy 4(^{d})</td>
<td>64</td>
<td>6.92</td>
<td>3.22</td>
<td>7.41</td>
<td>3.21</td>
<td>6.45</td>
<td>2.46</td>
</tr>
<tr>
<td>Training x Strategy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>None Received</td>
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<td></td>
</tr>
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<td>x Strategy 1</td>
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<td>6.49</td>
<td>2.63</td>
<td>5.31</td>
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<td>7.13</td>
<td>2.53</td>
</tr>
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<td>x Strategy 3</td>
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<td>7.28</td>
<td>3.42</td>
<td>7.70</td>
<td>3.06</td>
<td>5.98</td>
<td>2.80</td>
</tr>
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<td>6.80</td>
<td>3.21</td>
<td>7.97</td>
<td>2.94</td>
<td>6.49</td>
<td>2.48</td>
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<td>Received</td>
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<td>7.88</td>
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<td>6.24</td>
<td>1.85</td>
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<td>6.10</td>
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<td>6.72</td>
<td>3.43</td>
<td>6.41</td>
<td>2.47</td>
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</tbody>
</table>

Note: Maximum score possible = 20.00

\(^{a}\)Semantic maps only

\(^{b}\)Semantic maps & Adjunct post-questions

\(^{c}\)Semantic maps, Adjunct post-questions, & Metacognitive prompts

\(^{d}\)Semantic maps, Adjunct post-questions, Metacognitive prompts, & Cognitive feedback
Table 4.3: Mean Scores and Standard Deviations on Criterion Tests For All Treatment Groups - Delayed Testing

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>n</th>
<th>Identification M</th>
<th>SD</th>
<th>Terminology M</th>
<th>SD</th>
<th>Comprehension M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td></td>
<td></td>
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<tr>
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<td>3.33</td>
<td>6.89</td>
<td>3.08</td>
<td>5.59</td>
<td>2.24</td>
</tr>
<tr>
<td>Received</td>
<td>122</td>
<td>7.21</td>
<td>3.47</td>
<td>6.17</td>
<td>3.12</td>
<td>5.45</td>
<td>2.46</td>
</tr>
<tr>
<td>Strategy Used</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Strategy 1\textsuperscript{a}</td>
<td>69</td>
<td>7.01</td>
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<td>5.94</td>
<td>2.65</td>
<td>5.42</td>
<td>2.27</td>
</tr>
<tr>
<td>Strategy 2\textsuperscript{b}</td>
<td>67</td>
<td>7.57</td>
<td>3.51</td>
<td>6.75</td>
<td>3.04</td>
<td>5.70</td>
<td>2.13</td>
</tr>
<tr>
<td>Strategy 3\textsuperscript{c}</td>
<td>70</td>
<td>6.93</td>
<td>3.68</td>
<td>6.79</td>
<td>3.02</td>
<td>5.29</td>
<td>2.49</td>
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<td>7.41</td>
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<td>3.70</td>
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<td>2.48</td>
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<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x Strategy 1</td>
<td>35</td>
<td>7.37</td>
<td>2.73</td>
<td>5.89</td>
<td>2.46</td>
<td>5.51</td>
<td>2.16</td>
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<td>5.13</td>
<td>2.53</td>
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<td>3.77</td>
<td>7.46</td>
<td>3.97</td>
<td>6.09</td>
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<td>7.27</td>
<td>3.81</td>
<td>6.67</td>
<td>3.52</td>
<td>5.50</td>
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<td>3.47</td>
<td>6.03</td>
<td>3.23</td>
<td>5.31</td>
<td>2.66</td>
</tr>
</tbody>
</table>

Note. Maximum score possible = 20.00
\textsuperscript{a}Semantic maps only
\textsuperscript{b}Semantic maps & Adjunct post-questions
\textsuperscript{c}Semantic maps, Adjunct post-questions, & Metacognitive prompts
\textsuperscript{d}Semantic maps, Adjunct post-questions, Metacognitive prompts, & Cognitive feedback
Analysis of the Hypotheses

Hypothesis One

$H_0$: There will be insignificant differences in achievement of different learning outcomes across the varied semantic map treatments when training on strategies (semantic maps and metacognitive process prompts) is and is not provided to learners. The different learning outcomes were defined as a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an object; and c. understanding of complex procedures and processes, while the varied semantic map treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

As described in Chapter 3, an assessment of the correlations among the dependent variables was conducted to determine how to proceed with the quantitative analysis. For this study, Davis's (1971, p. 49) interpretation of a moderate correlation as $\pm 0.30$ to $0.49$ was used to determine whether or not a two-way MANOVA should be used. If the dependent variables were not found to be at least moderately correlated, then a two-way ANOVA individually conducted with each dependent variable would be an appropriate
analysis to use. Table 4.4 presents the Pearson correlation coefficients among the
dependent variables, or criterion tests, for both immediate and delayed testing periods.

Table 4.4: Pearson Correlation Coefficients Among the Criterion Tests

<table>
<thead>
<tr>
<th>Testing Period and Criterion Test</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Identification</td>
<td>--</td>
<td>.50**</td>
<td>.34**</td>
<td>.80**</td>
</tr>
<tr>
<td>2. Terminology</td>
<td>--</td>
<td>.54**</td>
<td>.85**</td>
<td></td>
</tr>
<tr>
<td>3. Comprehension</td>
<td>--</td>
<td></td>
<td>.74**</td>
<td></td>
</tr>
<tr>
<td>4. Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delayed Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Identification</td>
<td>--</td>
<td>.49**</td>
<td>.45**</td>
<td>.85**</td>
</tr>
<tr>
<td>2. Terminology</td>
<td>--</td>
<td>.33**</td>
<td>.79**</td>
<td></td>
</tr>
<tr>
<td>3. Comprehension</td>
<td>--</td>
<td></td>
<td>.70**</td>
<td></td>
</tr>
<tr>
<td>4. Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. n = 270.

**p < .01.

Because at least a moderate correlation existed among the dependent variables,
the assumption of homogeneity of variance-covariance matrices in MANOVA was tested
using the Box's M test. According to Tabachnick and Fidell (1996, p. 382), when sample
sizes are unequal, as is the case in this study, the assumption of homogeneity of variance-
covariance matrices can be violated if the Box's M test is found to be significant at p <
.001, such that the robustness of the significance tests of MANOVA cannot be
guaranteed. Therefore, Box's M tests were conducted on the three dependent variables
(scores on the Identification Test, Terminology Test, and Comprehension Test) and the two independent variables (receipt of training and strategy used) for both the first and second testing periods. Both Box's M tests revealed no significance at $p < .001$; therefore, the MANOVA assumption of variance-covariance matrices was met.

The multivariate normal distribution assumption was also confirmed by examining the skewness values of the dependent variables across the different combinations of the independent variables. Skewness values ranged from a low of -0.03 to a high of 1.56 with the majority of skewness values less than ±1.00, which is approximately normal and considered excellent for most psychometric purposes (George & Mallery, 2001, p. 87; Morgan, Griego, & Gloeckner, 2001, p. 67). The few skewness values that were greater than ±1.00 were less than ±2.00, which is still considered acceptable (George & Mallery, 2001, p. 87). Tabachnick and Fidell (1996, p. 381) lend further assurance that the normality assumption was met. According to the authors, the robustness to a violation of normality is ensured when the smallest cell in a MANOVA contains a sample size of 20. In this study, the smallest cell contained a sample size of 29.

Since the dependent variables were shown to be at least moderately correlated and the multivariate assumptions of variance-covariance matrices and normal distribution were met, a two-way MANOVA for each testing period was used to analyze data related to Hypothesis 1. Pillai's criterion was used to test the significance of the main effects and interactions because it is more robust than other multivariate statistics when unequal sample sizes exist, as is the case in this study (Tabachnick & Fidell, 1996, p. 401). The MANOVA results for each testing period are shown in Table 4.5.
For immediate and delayed testing, no significant differences were found on the criterion tests' scores among the varied semantic map treatments regardless of whether strategy training was or was not provided. Therefore, Hypothesis 1 was retained at the .05 level of significance.

**Hypothesis Two**

H₁: **Within** each of the four semantic map treatments, there will be significant differences between the immediate and delayed achievement of different learning outcomes when training on strategies (semantic maps and metacognitive prompts) is and is not provided to learners. The different learning outcomes were defined as a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an object; and c. understanding of complex procedures and processes, while the varied semantic map

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Pillai's Criterion</th>
<th>df</th>
<th>Multivariate F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Immediate Testing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training Provided</td>
<td>.001</td>
<td>3</td>
<td>.07</td>
</tr>
<tr>
<td>Strategy Used</td>
<td>.039</td>
<td>9</td>
<td>1.14</td>
</tr>
<tr>
<td>Training by Strategy</td>
<td>.057</td>
<td>9</td>
<td>1.68</td>
</tr>
<tr>
<td><strong>Delayed Testing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training Provided</td>
<td>.018</td>
<td>3</td>
<td>1.55</td>
</tr>
<tr>
<td>Strategy Used</td>
<td>.022</td>
<td>9</td>
<td>.65</td>
</tr>
<tr>
<td>Training by Strategy</td>
<td>.031</td>
<td>9</td>
<td>.91</td>
</tr>
</tbody>
</table>

*Table 4.5: Multivariate Analysis of Variance of Criterion Tests' Scores for Immediate and Delayed Testing*
treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

As stated in Chapter 3, a doubly repeated measures multivariate analysis of variance (MANOVA) with three dependent variables and time as the within-factor variable was used to analyze Hypothesis 2 once it was found that all required assumptions were met (Tabachnick & Fidell, 2001b, pp. 423-429). The three dependent measures were the Identification Test, Terminology Test, and Comprehension Test scores. The within-factor variable, time, had two levels--immediate and repeat testing periods.

Since at least a moderate correlation among the dependent variables was already established in the analysis of Hypothesis 1 and the multivariate normal distribution assumption was previously shown to be satisfied, only the assumption of homogeneity of variance-covariance matrices required examination. This assumption was tested and met using the Box's M test which revealed no significance at $p < .001$ (per Tabachnick and Fidell, 1996, p. 382).

Having met all assumptions, a doubly repeated measures MANOVA with the three dependent variables and time as the within-factor variable was conducted. As in the analysis of Hypothesis 1, Pillai's criterion was used to test the significance of the main
effect, time, and the interactions for Hypothesis 2. The results of the doubly repeated measures MANOVA are presented in Table 4.6.

Table 4.6: Doubly Repeated Measures Multivariate Analysis of Variance of Criterion Tests' Scores with the Within-Factor Variable of Time

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Pillai’s Criterion</th>
<th>df</th>
<th>Multivariate F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>.145</td>
<td>3</td>
<td>14.72***</td>
</tr>
<tr>
<td>Time by Training Provided</td>
<td>.011</td>
<td>3</td>
<td>.95</td>
</tr>
<tr>
<td>Time by Strategy Used</td>
<td>.042</td>
<td>9</td>
<td>1.24</td>
</tr>
<tr>
<td>Time by Training by Strategy</td>
<td>.042</td>
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<td>1.23</td>
</tr>
</tbody>
</table>

***p < .001

While no significant interactions were found, the main effect within-factor variable of time was shown to be significant at the .001 level of significance. Therefore, to identify within which dependent measure--Identification Test, Terminology Test, and/or Comprehension Test--significant differences between testing periods were to be found, the epsilon adjustment Huynh-Feldt test was used since sphericity could not be assumed because the results of the Mauchly test of sphericity revealed a p value less than .05 (Tabachnick & Fidell, 2001a, pp. 291-292). Table 4.7 presents the results for each of the dependent measures for the main effect of time.
Huynh-Feldt test results showed that there were no significant differences between testing periods on the Identification Test scores while significant differences existed between testing periods on both the Terminology and Comprehension Test scores. Therefore, to further identify where the differences existed, one-sample t tests were conducted.

In order to conduct the one-sample t tests, test score differences were calculated between immediate and delayed testing for all criterion tests within each treatment group by subtracting the test scores achieved in delayed testing from those achieved in immediate testing. A test score difference that was not significantly different from a value of 0 would indicate that the test score achieved in immediate testing was not significantly different from that achieved in delayed testing. The one-sample t test examined whether or not the test score difference value was significantly different from zero (0) at the .025 level of significance. Table 4.8, Table 4.9, and Table 4.10 present the results of the one-sample t tests.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
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<td>.77</td>
<td>31.63***</td>
<td>16.96***</td>
</tr>
<tr>
<td>Error</td>
<td>262</td>
<td>(5.11)</td>
<td>(4.39)</td>
<td>(3.90)</td>
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</table>

Note. Values enclosed in parentheses represent mean square errors.

***p < .001
Table 4.8: One-Sample t Test Comparisons and Means for Treatment Main Effects

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Immediate Testing</th>
<th>Delayed Testing</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Criterion Test</td>
<td>M</td>
<td>Criterion Test</td>
<td>M</td>
<td>p</td>
</tr>
<tr>
<td>Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None Received</td>
<td>Identification</td>
<td>7.41</td>
<td>vs Identification</td>
<td>7.23</td>
<td>.493</td>
</tr>
<tr>
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<td>Terminology</td>
<td>7.62</td>
<td>vs Terminology</td>
<td>6.89</td>
<td>.002</td>
</tr>
<tr>
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<td>Comprehension</td>
<td>6.24</td>
<td>vs Comprehension</td>
<td>5.59</td>
<td>.004</td>
</tr>
<tr>
<td>Received</td>
<td>Identification</td>
<td>7.44</td>
<td>vs Identification</td>
<td>7.21</td>
<td>.448</td>
</tr>
<tr>
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<td>Terminology</td>
<td>7.52</td>
<td>vs Terminology</td>
<td>6.17</td>
<td>.000</td>
</tr>
<tr>
<td>Received</td>
<td>Comprehension</td>
<td>6.25</td>
<td>vs Comprehension</td>
<td>5.45</td>
<td>.003</td>
</tr>
<tr>
<td>Strategy Used</td>
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<td></td>
<td></td>
</tr>
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<td>Strategy 1(^a)</td>
<td>Identification</td>
<td>7.78</td>
<td>vs Identification</td>
<td>7.01</td>
<td>.068</td>
</tr>
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<td>Terminology</td>
<td>7.38</td>
<td>vs Terminology</td>
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<td>.000</td>
</tr>
<tr>
<td>Strategy 1(^a)</td>
<td>Comprehension</td>
<td>5.77</td>
<td>vs Comprehension</td>
<td>5.42</td>
<td>.268</td>
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<td>vs Identification</td>
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<td>vs Terminology</td>
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<td>vs Comprehension</td>
<td>5.70</td>
<td>.001</td>
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<td>Identification</td>
<td>7.27</td>
<td>vs Identification</td>
<td>6.93</td>
<td>.306</td>
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<td>Terminology</td>
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<td>vs Terminology</td>
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<td>.061</td>
</tr>
<tr>
<td>Strategy 3(^c)</td>
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<td>6.03</td>
<td>vs Comprehension</td>
<td>5.29</td>
<td>.048</td>
</tr>
<tr>
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<td>6.92</td>
<td>vs Identification</td>
<td>7.41</td>
<td>.248</td>
</tr>
<tr>
<td>Strategy 4(^d)</td>
<td>Terminology</td>
<td>7.41</td>
<td>vs Terminology</td>
<td>6.81</td>
<td>.170</td>
</tr>
<tr>
<td>Strategy 4(^d)</td>
<td>Comprehension</td>
<td>6.45</td>
<td>vs Comprehension</td>
<td>5.73</td>
<td>.059</td>
</tr>
</tbody>
</table>

Note. Maximum score possible = 20.00

\(^a\)Semantic maps only
\(^b\)Semantic maps & Adjunct post-questions
\(^c\)Semantic maps, Adjunct post-questions, & Metacognitive prompts
\(^d\)Semantic maps, Adjunct post-questions, Metacognitive prompts, & Cognitive feedback
For Persons Who Did Not Receive Training

The one-sample t tests revealed that several test score difference values were not significantly different from zero, indicating that several test scores achieved in immediate testing were not significantly different from those achieved one week later in delayed testing. Table 4.8 presents results that show this was the case for the Identification Test score for the main effect, Training. The Identification Test score achieved in immediate testing (M=7.41, SD=3.36) was not significantly different from the Identification Test score achieved in delayed testing (M=7.23, SD=3.33). There was no significant decrease in Identification Test scores. However, there were significant decreases in the Terminology Test and Comprehension Test scores from immediate to delayed testing. For the Terminology Test score, the mean score dropped from 7.62 (SD=2.86) to 6.89 (SD=3.08) from immediate to delayed testing. In the Comprehension Test, the mean scores dropped from 6.24 (SD=2.48) to 5.59 (SD=2.24).

For Persons Who Received Training

In the training situation, the results were similar to those in the no training situation. The Identification Test score achieved in immediate testing (M=7.44, SD=3.47) was not significantly different from the Identification Test score achieved in delayed testing (M=7.21, SD=3.47). There was no significant decrease in Identification Test scores. However, there were significant decreases in the Terminology Test and Comprehension Test scores from immediate to delayed testing. For the Terminology
Test, the mean score dropped from 7.52 (SD=3.36) to 6.17 (SD=3.12) from immediate to delayed testing. In the Comprehension Test, the mean scores dropped from 6.25 (SD=2.59) to 5.45 (SD=2.46).

For Persons Who Used Strategy 1—Semantic Maps

Table 4.8 also presents results which show that within the main effect, Strategy, several mean score difference values were not significantly different from zero. This was the case in the Identification Test and Comprehension Test for Strategy 1. The Identification Test score achieved in immediate testing ($M=7.78$, $SD=3.27$) was not significantly different from the Identification Test score achieved in delayed testing ($M=7.01$, $SD=2.75$). The Comprehension Test score achieved in immediate testing ($M=5.77$, $SD=2.51$) was not significantly different from the Comprehension Test score achieved in delayed testing ($M=5.42$, $SD=2.27$). There were no significant decreases in Identification Test scores and in Comprehension Test scores. However, there was a significant decrease in the Terminology Test scores from immediate to delayed testing. For the Terminology Test score, the mean score dropped from 7.38 (SD=3.10) to 5.94 (SD=2.65) from immediate to delayed testing.

For Persons Who Used Strategy 2—Semantic Maps and Adjunct Post-Questions

For participants who used Strategy 2, Table 4.8 shows that only one non-significant result was found. The Identification Test score achieved in immediate testing
(M=7.69, SD=3.65) was not significantly different from the Identification Test score achieved in delayed testing (M=7.57, SD=3.51). There was no significant decrease in Identification Test scores. However, there were significant decreases in the Terminology Test and Comprehension Test scores from immediate to delayed testing. For the Terminology Test score, the mean score dropped from 8.06 (SD=2.76) to 6.75 (SD=3.04) from immediate to delayed testing. In the Comprehension Test, the mean scores dropped from 6.75 (SD=2.29) to 5.70 (SD=2.13).

For Persons Who Used Strategy 3—Semantic Maps, Adjunct Post-Questions, and Metacognitive Prompts

For participants who used Strategy 3, Table 4.8 shows that mean score difference values were not significantly different from zero at the .025 level of significance for each criterion test. There were no significant decreases in Identification Test scores, in Terminology Test scores, and in Comprehension Test scores.

For Persons Who Used Strategy 4—Semantic Maps, Adjunct Post-Questions, Metacognitive Prompts, and Cognitive Feedback

For participants who used Strategy 4, results presented in Table 4.8 show that mean score difference values were not significant from zero at the .025 level of significance for each criterion test. There were no significant decreases in Identification Test scores, in Terminology Test scores, and in Comprehension Test scores.
### Table 4.9: One-Sample t Test Group Comparisons Across Testing Periods for Strategies in the No Training Situation

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Immediate Testing</th>
<th>Delayed Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Criterion Test</td>
<td>M</td>
</tr>
<tr>
<td>No Training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Identification</td>
<td>7.69</td>
</tr>
<tr>
<td>x Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Terminology</td>
<td>6.49</td>
</tr>
<tr>
<td>x Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Comprehension</td>
<td>5.31</td>
</tr>
<tr>
<td>x Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Identification</td>
<td>7.84</td>
</tr>
<tr>
<td>x Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Terminology</td>
<td>8.26</td>
</tr>
<tr>
<td>x Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Comprehension</td>
<td>7.13</td>
</tr>
<tr>
<td>x Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Identification</td>
<td>7.28</td>
</tr>
<tr>
<td>x Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Terminology</td>
<td>7.70</td>
</tr>
<tr>
<td>x Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Comprehension</td>
<td>5.98</td>
</tr>
<tr>
<td>x Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Identification</td>
<td>6.80</td>
</tr>
<tr>
<td>x Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Terminology</td>
<td>7.97</td>
</tr>
<tr>
<td>x Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Comprehension</td>
<td>6.49</td>
</tr>
</tbody>
</table>

**Note.** Maximum score possible = 20.00

<sup>a</sup>Semantic maps only

<sup>b</sup>Semantic maps & Adjunct post-questions

<sup>c</sup>Semantic maps, Adjunct post-questions, & Metacognitive prompts

<sup>d</sup>Semantic maps, Adjunct post-questions, Metacognitive prompts, & Cognitive feedback
For Persons in the No Training Situation Who Used Strategy 1—Semantic Maps

For participants in the no training situation who used Strategy 1, results presented in Table 4.9 show that mean score difference values were not significant from zero for
each criterion test. There were no significant decreases in Identification Test scores, in Terminology Test scores, and in Comprehension Test scores.

For Persons in the No Training Situation Who Used Strategy 2—Semantic Maps and Adjunct Post-Questions

For participants in the no training situation who used Strategy 2, Table 4.9 shows that two non-significant results were found. The Identification Test score achieved in immediate testing ($M=7.84$, $SD=3.62$) was not significantly different from the Identification Test score achieved in delayed testing ($M=7.47$, $SD=3.14$). The Terminology Test score achieved in immediate testing ($M=8.26$, $SD=2.59$) was not significantly different from the Terminology Test score achieved in delayed testing ($M=7.32$, $SD=3.00$). There were no significant decreases in Identification Test scores and Terminology Test scores. However, there was a significant decrease in the Comprehension Test scores from immediate to delayed testing. In the Comprehension Test, the mean scores dropped from 7.13 ($SD=2.53$) to 5.71 ($SD=1.90$).

For Persons in the No Training Situation Who Used Strategy 3—Semantic Maps, Adjunct Post-Questions, and Metacognitive Prompts

For participants in the no training situation who used Strategy 3, results presented in Table 4.9 show that mean score difference values were not significant from zero for
each criterion test. There were no significant decreases in Identification Test scores, in Terminology Test scores, and in Comprehension Test scores.

For Persons in the No Training Situation Who Used Strategy 4—Semantic Maps, Adjunct Post-Questions, Metacognitive Prompts, and Cognitive Feedback

For participants in the no training situation who used Strategy 4, results presented in Table 4.9 show that mean score difference values were not significant from zero for each criterion test. There were no significant decreases in Identification Test scores, in Terminology Test scores, and in Comprehension Test scores.

For Persons in the Training Situation Who Used Strategy 1—Semantic Maps

For participants in the training situation who used Strategy 1, Table 4.10 shows that two non-significant results were found. The Identification Test score achieved in immediate testing ($M=7.88$, $SD=3.38$) was not significantly different from the Identification Test score achieved in delayed testing ($M=6.65$, $SD=2.75$). The Comprehension Test score achieved in immediate testing ($M=6.24$, $SD=3.12$) was not significantly different from the Comprehension Test score achieved in delayed testing ($M=5.32$, $SD=2.41$). There were no significant decreases in Identification Test scores and Comprehension Test scores. However, there was a significant decrease in the
Terminology Test scores from immediate to delayed testing. In the Terminology Test, the scores dropped from 8.29 ($SD=3.32$) to 6.00 ($SD=2.87$).

For Persons in the Training Situation Who Used Strategy 2—Semantic Maps and Adjunct Post-Questions

For participants in the training situation who used Strategy 2, Table 4.10 shows that two non-significant results were found. The Identification Test score achieved in immediate testing ($M=7.48$, $SD=3.75$) was not significantly different from the Identification Test score achieved in delayed testing ($M=7.69$, $SD=3.99$). The Comprehension Test score achieved in immediate testing ($M=6.24$, $SD=1.85$) was not significantly different from the Comprehension Test score achieved in delayed testing ($M=5.69$, $SD=2.42$). There were no significant decreases in Identification Test scores and in Comprehension Test scores. However, there was a significant decrease in the Terminology Test scores from immediate to delayed testing. For the Terminology Test score, the score dropped from 7.79 ($SD=2.99$) to 6.00 ($SD=2.98$) from immediate to delayed testing.

For Persons in the Training Situation Who Used Strategy 3—Semantic Maps, Adjunct Post-Questions, and Metacognitive Prompts

For participants in the training situation who used Strategy 3, Table 4.10 shows that mean score difference values were not significant from zero for each criterion test.
There were no significant decreases in Identification Test scores, in Terminology Test scores, and in Comprehension Test scores.

For Persons in the Training Situation Who Used Strategy 4—Semantic Maps, Adjunct Post-Questions, Metacognitive Prompts, and Cognitive Feedback

For participants in the training situation who used Strategy 4, Table 4.10 shows that mean score difference values were not significant from zero at the .025 level of significance for each criterion test. There were no significant decreases in Identification Test scores, in Terminology Test scores, and in Comprehension Test scores.
Chapter 5

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to determine the effects of different adjunct processing strategies in complementing semantic maps embedded within instructional text on student achievement of different types of learning outcomes. Specifically, it sought to examine the effects of adjunct post-questions, metacognitive process prompts, and cognitive feedback in complementing semantic maps embedded within an expository text passage on the immediate and delayed achievement of three types of learning outcomes: 1) knowledge of specific facts, terms, and definitions; 2) ability to identify parts or positions of an object; and 3) understanding of complex procedures and processes, when training on semantic maps and metacognitive process prompts is and is not provided to learners.

As presented in Table 3.5 in Chapter 3, the study consisted of a total of eight treatment groups—Treatments 1 through 4 in Group A and Treatments 1 through 4 in Group B. Subjects in Group A did not receive training on semantic maps and metacognitive process prompts, while subjects in Group B did receive strategy training. Subjects in Treatment 1 viewed the heart instruction with 13 embedded semantic maps. In Treatment 2, one adjunct question followed every semantic map. Subjects in Treatment 3 viewed the heart instruction with 13 embedded semantic maps and 13 adjunct questions. However, unlike Treatment 2, one metacognitive process prompt
followed every adjunct question. Lastly, subjects in Treatment 4 received all embedded strategies, including cognitive feedback which followed each of the 13 metacognitive process prompts. This chapter presents a discussion of the study's results given in Chapter 4, conclusions from the study, and recommendations for future research. Each hypothesis is restated and the results for each are summarized prior to the discussion of the results.

**Hypothesis One**

**H_{0}:** There will be insignificant differences in the immediate and in the delayed achievement of different learning outcomes across the varied semantic map treatments when training on strategies (semantic maps and metacognitive process prompts) is and is not provided to learners. The different learning outcomes were defined as a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an object; and c. understanding of complex procedures and processes, while the varied semantic map treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

Hypothesis 1 was retained at the .05 level of significance. When subjects were tested immediately after the computer instruction, no significant differences were found on the criterion tests' scores among the strategy treatments regardless of whether or not
strategy training was provided. When subjects were tested one week after the immediate testing, no significant differences were found on the criterion tests’ scores among the strategy treatments regardless of whether or not strategy training was provided. Table 5.1 summarizes the results for Hypothesis 1. The table shows that there were no significant differences between the test scores of Group A (A) and Group B (B) for both immediate testing and delayed testing. There were also no significant differences among the test scores of those who used Strategy 1 (1), Strategy 2 (2), Strategy 3 (3), and Strategy 4 (4) for both immediate testing and delayed testing. Lastly, there were no significant differences among those in Group A who used Strategy 1 (A1), those in Group A who used Strategy 2 (A2), those in Group A who used Strategy 3 (A3), those in Group A who used Strategy 4 (A4), those in Group B who used Strategy 1 (B1), those in Group B who used Strategy 2 (B2), those in Group B who used Strategy 3 (B3), and those in Group B who used Strategy 4 (B4).
Hypothesis Two

$H_1$: Within each of the four semantic map treatments, there will be significant differences between the immediate and delayed achievement of different learning outcomes when training on strategies (semantic maps and metacognitive prompts) is and is not provided to learners. The different learning outcomes were defined as: a. knowledge of specific facts, terms, and definitions; b. ability to identify parts or positions of an object; and c. 

### Table 5.1: Summary of Results for Hypothesis 1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training Group</td>
<td>$A^a=B^b$</td>
<td>$A=B$</td>
<td>$A=B$</td>
</tr>
<tr>
<td>Strategy Used</td>
<td>$1^c=2^d=3^e=4^f$</td>
<td>$1=2=3=4$</td>
<td>$1=2=3=4$</td>
</tr>
<tr>
<td>Training Group by Strategy</td>
<td>$A1=A2=A3=A4=$</td>
<td>$A1=A2=A3=A4=$</td>
<td>$A1=A2=A3=A4=$</td>
</tr>
<tr>
<td>Delayed Testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training Group</td>
<td>$A=B$</td>
<td>$A=B$</td>
<td>$A=B$</td>
</tr>
<tr>
<td>Strategy Used</td>
<td>$1=2=3=4$</td>
<td>$1=2=3=4$</td>
<td>$1=2=3=4$</td>
</tr>
<tr>
<td>Training Group by Strategy</td>
<td>$A1=A2=A3=A4=$</td>
<td>$A1=A2=A3=A4=$</td>
<td>$A1=A2=A3=A4=$</td>
</tr>
</tbody>
</table>

*Group A: No strategy training received
*Group B: Strategy training received on semantic maps and, if applicable, metacognitive process prompts
*Strategy 1: Semantic maps only
*Strategy 2: Semantic maps & Adjunct post-questions
*Strategy 3: Semantic maps, Adjunct post-questions, & Metacognitive prompts
*Strategy 4: Semantic maps, Adjunct post-questions, Metacognitive prompts, & Cognitive feedback
understanding of complex procedures and processes, while the varied semantic map treatments were identified as a. embedded semantic maps only (control); b. embedded semantic maps and adjunct post-questions; c. embedded semantic maps, adjunct post-questions, and metacognitive process prompts; and d. embedded semantic maps, adjunct post-questions, metacognitive process prompts, and cognitive feedback.

Hypothesis 2 could not be retained at the .025 level of significance. Table 5.2 and Table 5.3 provide summaries of the p values for the one-sample t test comparisons across testing periods. The information in these tables are based on the results presented in Tables 4.8, 4.9, and 4.10 in Chapter 4. The purpose of Table 5.2 and Table 5.3 is to present the information in a format that allows the reader to more easily make comparisons across criterion measures and treatment groups. In Tables 5.2 and 5.3, a p value that is greater than .025 (e.g., any p value appearing in the far right-hand column of Tables 5.2 and 5.3) verifies that within the particular treatment, the test score achieved in immediate testing was not significantly different from the test score achieved in delayed testing. In other words, one week after viewing the instruction, information loss or decay of learned material did not occur as was hypothesized.
Table 5.2: p Values for One-Sample t Test Comparisons Across Testing Periods for Treatment Main Effects

<table>
<thead>
<tr>
<th>Criterion Test by Treatment</th>
<th>p Values for Immediate vs. Delayed Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p ≤ .025</td>
</tr>
<tr>
<td></td>
<td>p &gt; .025</td>
</tr>
<tr>
<td>Identification</td>
<td></td>
</tr>
<tr>
<td>No Training</td>
<td>.493</td>
</tr>
<tr>
<td>Training</td>
<td>.448</td>
</tr>
<tr>
<td>Terminology</td>
<td></td>
</tr>
<tr>
<td>No Training</td>
<td>.002</td>
</tr>
<tr>
<td>Training</td>
<td>.000</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
</tr>
<tr>
<td>No Training</td>
<td>.004</td>
</tr>
<tr>
<td>Training</td>
<td>.003</td>
</tr>
<tr>
<td>Identification</td>
<td></td>
</tr>
<tr>
<td>Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.068</td>
</tr>
<tr>
<td>Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.760</td>
</tr>
<tr>
<td>Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.306</td>
</tr>
<tr>
<td>Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.248</td>
</tr>
<tr>
<td>Terminology</td>
<td></td>
</tr>
<tr>
<td>Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.000</td>
</tr>
<tr>
<td>Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
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</tr>
<tr>
<td>Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.170</td>
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<tr>
<td>Comprehension</td>
<td></td>
</tr>
<tr>
<td>Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.268</td>
</tr>
<tr>
<td>Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.048</td>
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<tr>
<td>Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.059</td>
</tr>
</tbody>
</table>

<sup>a</sup>Semantic maps only
<sup>b</sup>Semantic maps & Adjunct post-questions
<sup>c</sup>Semantic maps, Adjunct post-questions, & Metacognitive prompts
<sup>d</sup>Semantic maps, Adjunct post-questions, Metacognitive prompts, & Cognitive feedback
Table 5.2 and Table 5.3 allow one to more easily make comparisons across criterion measures and treatment groups and see where deviations exist. For example, regardless of whether or not subjects received strategy training, among the three criterion measures, the following comparisons were made:

<table>
<thead>
<tr>
<th>Criterion Test by Strategy in No Training Situation</th>
<th>Immediate vs. Delayed Testing</th>
<th>p ≤ .025</th>
<th>p &gt; .025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification</td>
<td>p ≤ .025</td>
<td>Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.588</td>
</tr>
<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.046</td>
</tr>
<tr>
<td></td>
<td>p ≤ .025</td>
<td>Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.472</td>
</tr>
<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.738</td>
</tr>
<tr>
<td></td>
<td>p ≤ .025</td>
<td>Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.184</td>
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<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.000</td>
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<tr>
<td></td>
<td>p ≤ .025</td>
<td>Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.218</td>
</tr>
<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.685</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criterion Test by Strategy in Training Situation</th>
<th>Immediate vs. Delayed Testing</th>
<th>p ≤ .025</th>
<th>p &gt; .025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification</td>
<td>p ≤ .025</td>
<td>Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.046</td>
</tr>
<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>p ≤ .025</td>
<td>Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.043</td>
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<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td>p ≤ .025</td>
<td>Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.058</td>
</tr>
<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.435</td>
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<tr>
<td></td>
<td>p ≤ .025</td>
<td>Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.386</td>
</tr>
<tr>
<td></td>
<td>p &gt; .025</td>
<td>Strategy 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.287</td>
</tr>
</tbody>
</table>

| Comprehension                                      | p ≤ .025 | Strategy 1<sup>a</sup> | .560  |
|                                                    | p > .025 | Strategy 1<sup>a</sup> | .085  |
|                                                    | p ≤ .025 | Strategy 2<sup>b</sup> | .000  |
|                                                    | p > .025 | Strategy 2<sup>b</sup> | .295  |
|                                                    | p ≤ .025 | Strategy 3<sup>c</sup> | .080  |
|                                                    | p > .025 | Strategy 3<sup>c</sup> | .321  |
|                                                    | p ≤ .025 | Strategy 4<sup>d</sup> | .466  |
|                                                    | p > .025 | Strategy 4<sup>d</sup> | .036  |

<sup>a</sup>Semantic maps only
<sup>b</sup>Semantic maps & Adjunct post-questions
<sup>c</sup>Semantic maps, Adjunct post-questions, & Metacognitive prompts
<sup>d</sup>Semantic maps, Adjunct post-questions, Metacognitive prompts, & Cognitive feedback
tests, only the Identification Test scores achieved in immediate testing were not significantly different from those achieved in the delayed testing; this was not true for the Terminology Test and Comprehension Test scores. As for strategy treatments that stand out, only for Strategy 2 (Semantic Maps and Adjunct Post-Questions) did Comprehension Test scores achieved in immediate testing significantly decrease in delayed testing. The same was true for Comprehension Test scores in the no training situation. However, it was not true for those in the training situation. For Terminology Test scores, only for Strategy 3 (Semantic Maps, Adjunct Post-Questions, and Metacognitive Process Prompts) and Strategy 4 (Semantic Maps, Adjunct Post-Questions, Metacognitive Process Prompts, and Cognitive Feedback) were test scores achieved in immediate testing not significantly different from those achieved in delayed testing. The same was true for Terminology Test scores in the training situation, but it was not true for those achieved in the no training situation. A discussion of the findings follows.

Discussion and Conclusions

This study focused on the immediate and delayed achievement of three learning outcomes. They are:

Learning Outcome 1 (LO1): The knowledge of specific facts, terms, and definitions as measured by the Terminology Test;

Learning Outcome 2 (LO2): The ability to identify parts or positions of an object as measured by the Identification Test; and
Learning Outcome 3 (LO3): The understanding of complex procedures and processes as measured by the Comprehension Test.

Reference is made to the three learning outcomes within the discussion of the results.

**Effect of Strategy Training**

It was found that when training on strategies (semantic maps and metacognitive process prompts) was and was not provided to learners, there were no significant differences in immediate achievement and in delayed achievement for all three learning outcomes—LO1, LO2, and LO3. In addition, strategy training did not prevent information loss or decay of learned material for both LO1 and LO3. As for LO2, although those who received strategy training were shown not to have experienced information decay of learned material after one week, the retention of learned material for LO2 cannot be attributed to the strategy training. This is because those who did not receive strategy training were also shown to have no significant differences in immediate and delayed achievement of LO2. Therefore, based on the results of this study, training on embedded semantic maps and training on metacognitive process prompts do not facilitate both the immediate and delayed achievement of LO1, LO2, and LO3 and do not prevent the information decay of learned material for LO1, LO2, and LO3 after one week. This finding is contrary to the suggestion by researchers of embedded maps (e.g., Lee, 1997 and Roshan, 1997) and of metacognitive process prompts and verbalizations or self-explanations (e.g., Berry & Broadbent, 1984 and Lin, 1993) that training should be provided to learners when these strategies are used.
Berry and Broadbent (1984) proposed that verbalization or self-explanation, as with metacognitive process prompts, might not have a significant effect unless it is accompanied by training on how to respond to questions requesting verbalization or explanation in order to help learners to attend to the relevant or appropriate information when generating their explanation and to make the information available in working memory. Without training, explanations may be generated from whatever information is available at the time (Ericsson & Simon, 1980). It could be that subjects' attention was already focused on the relevant information due to the selective attention function (Mayer, 1984) of the embedded semantic maps and the specific backwards processing effect (Rickards & Denner, 1978) of the adjunct questions received prior to the metacognitive process prompts. Therefore, training on the metacognitive process prompts might not have been needed to help learners attend to the relevant information when generating their explanations.

Another reason why the training did not produce significant differences in achievement could have been due to the quantity and content of the training. In this study, training sessions on semantic maps and training sessions on metacognitive process prompts were each one hour in length. In Weinstein and Mayer's (1986) discussion on strategy training, one study (Bommarito & Meichenbaum, 1978) that was focused upon found superior immediate and delayed performance on a test of reading comprehension. However, this was after subjects participated in six 45-minute strategy training sessions on monitoring their comprehension. The content of the multiple training sessions involved not only modeling of the use of the strategies and self-verbalization, but also
practice on using the strategies and making self-statements. In the current study, focus was placed on modeling the strategies to the participants. It could be that with additional training sessions that included practice on using the strategies, subjects who received strategy training could have significantly outperformed those who did not receive strategy training. Therefore, future research that incorporates semantic maps and metacognitive process prompts could lengthen the amount of training provided on these strategies and include practice sessions on using the strategies.

**Effect of Strategy Treatment Used**

It was found that there were no significant differences in immediate achievement and in delayed achievement for all three learning outcomes--LO1, LO2, and LO3--across the different semantic map treatments. Therefore, none of the adjunct processing strategies intended to complement the semantic maps, based on the intended learning outcomes described in Chapter 2, were effective in enhancing the achievement of the three learning outcomes. This is somewhat surprising because learners who received one or more strategies in addition to semantic maps were observed to have spent more time on the instruction than those whose instruction contained only semantic maps and, thus, had the opportunity to process the relevant information associated with the three learning outcomes for a longer period of time. Time on task is considered to be a powerful factor in learning (W. Dick, personal communication, December 11, 2000), yet this study indicates otherwise. It could be that the addition of adjunct questions, metacognitive process prompts, and cognitive feedback, although increasing subjects' time on task, also
overwhelmed subjects' cognitive resources. This could have occurred particularly with the subjects who received metacognitive prompts since the act of monitoring can increase cognitive demands and overwhelm learners (Butler & Winne, 1995). The increase in cognitive demands could have been due to the number of cues that subjects were attempting to monitor (e.g., the several concepts, categories, and relationships within the embedded semantic maps and the concepts, relationships, and procedures found in the adjunct post-questions) (Kanfer & Ackerman, 1989). The addition of feedback could have cued deep processing of the content (Butler & Winne, 1995), further increasing cognitive demands. Although the cognitive feedback was intended to support subjects' monitoring, it could have further increased demands on cognitive processing and overwhelmed cognitive resources by identifying the ways in which monitoring could have occurred with the numerous cues.

Another reason why significant differences were not found among the achievement of the strategy treatment groups on the three learning outcomes could be that the strategies selected, although shown in the literature (e.g., Chi et al., 1989; Hamaker, 1986; Kluger & DeNisi, 1996) to be effective when used alone, were: a) not the appropriate ones to use in combination with semantic maps, b) not the appropriate strategies to use with the population used in this study, and/or c) not the appropriate strategies to use for the types of learning outcomes used in this study, in order to obtain a significant enhancement in achievement for the three learning outcomes. This could be why certain researchers have advocated that it is critical to not only examine which strategy forms are effective, but also when (e.g., under what conditions, with which
learners, and for which measured learning outcomes) (Berardi-Coletta et al., 1995; Butler & Winne, 1995; Hamaker, 1986; Hamilton, 1985; Kluger & DeNisi, 1996; Lin et al., 1999; and Robinson, 1998).

Another explanation for insignificant differences among the strategy treatment groups could be that for the very reasons that make semantic maps beneficial—computational efficiency (Larkin & Simon, 1987; Waller, 1981) and selective attention to important concepts and relationships (Mayer, 1984), an adverse effect was created instead. The computational efficiency of semantic maps could have caused learners to exert too little effort when encoding the information represented in the map, as Robinson & Schraw (1994) have hypothesized. In addition, the selective attention function of semantic maps could have caused learners to focus their attention upon only the information contained in the maps because they saw that the instruction selected it out for further study (Mayer, 1984). Attending to only the relevant material, or the material for which the semantic maps were meant to help process based on the initial item analysis conducted in the first pilot study, could have directed learners' attention away from the other parts of the text passage which were still needed to enhance achievement of the three learning outcomes.

A fourth explanation is that the adjunct questions used may have created either: a) a specific backward processing effect in which students only reviewed the relevant material needed to answer the questions and ignored the incidental information that one may pick up when reviewing material or b) a specific forward processing effect in which students only attend to the material that questions seem to be asking for and ignore the
other non-relevant material (Rickards & Denner, 1978). This second case is very possible since the adjunct questions used in this study had a tendency to ask students to describe relationships between structures within blood flow processes. Students, therefore, could have easily developed a "set" to attend to only this type of information. Attending to only the relevant material, or the material for which the adjunct questions were meant to help process based on the initial item analysis conducted in the first pilot study, may have directed learners' attention away from the other parts of the text passage which were still needed to enhance achievement of the three learning outcomes. If the semantic maps and/or adjunct questions created such an adverse focusing effect, then the metacognitive process prompts and cognitive feedback, which also directed learners' attention to the relevant material, could have exacerbated the situation.

Finally, it is also quite possible that because the content of the instruction was not related to the students' major field or coursework and because students did not receive any form of compensation (e.g., additional class credit) for their participation in the study, students' motivation could very well have been low enough such that little effort was put forth on: a) understanding the content, b) using the strategies, and/or c) selecting the correct responses to the criterion tests' questions, regardless of which strategy treatment students received. A lack of motivation to expend the effort needed to apply a strategy is considered to be one of the four types of problems in strategy application (Butler & Winne, 1995, p. 259). Therefore, the strategy could be effective but only when the learner actively utilizes it. For example, the cognitive feedback used in this study was thought to contain useful information, but Bangert-Drowns et al. (1991, p. 214)
concluded that the effectiveness of feedback is based upon whether it "...empowers active learners with strategically useful information..." The emphasis here is on "active" learners who are motivated to use the strategy.

An indication that little effort was put forth by subjects in completely comprehending the material was the consistent yet rather low reliabilities achieved on the criterion measures, presented in Table 4.1 in Chapter 4. Statisticians (e.g., Thorndike, Cunningham, Thorndike, & Hagen, 1991) have stated that if a group of test items are based on a single common reference material or passage, performance on the items "...will depend to some extent on the common act of comprehending the reference materials" (p. 99). Therefore, when students do not completely comprehend the materials that the criterion measures have been designed to assess the comprehension of, reliabilities will be lowered even if the criterion measures are valid. The rather low mean scores on the criterion tests during immediate testing could also be an indication that students exerted little effort in trying to comprehend the instructional material. Mean scores ranged from a low of 5.31 (out of a possible 20) on the Comprehension Test to a high of 8.29 (out of a possible 20) on the Terminology Test. This could also be an indication that students put forth little effort in selecting the correct responses to the questions on the criterion tests.

Upon examination of the effect of the strategy on preventing information decay of learned material, results vary for each of the three learning outcomes. For LO1 (knowledge of specific facts, terms, and definitions), Strategy 1 (semantic maps only) and Strategy 2 (semantic maps and adjunct questions) did not prevent information decay of
learned material. However, with the addition of metacognitive process prompts, as found in Strategy 3 and Strategy 4, there was a lack of information decay of learned material one week after viewing the instruction. Therefore, it was thought that the metacognitive process prompts could be facilitating the retention of learned material.

In Lin's (1993) research, she found that subjects who received metacognitive prompts showed superior performance on far transfer problems than subjects who did not receive metacognitive prompts. However, no difference was found in performance on near transfer problems between the two groups. To explain this finding, she hypothesized that the change in complexity and context from near to far transfer problems made subjects, who received metacognitive prompts, spontaneously engage in metacognitive learning processes while solving the far transfer problem, thereby improving their performance. This is because metacognitive prompts can make learners focus more on how they are processing the information and what they are doing to answer a question (Lin, 1993). Somewhat similar to Lin's (1993) explanation, it could be that subjects who were exposed to the metacognitive process prompts in this study did not engage in recall of the processes used to answer the adjunct questions to assist them in answering the Terminology Test questions until testing was delayed. The one week delay in testing could have required a sufficient amount of effort to answer the Terminology Test questions, which in turn evoked learners to recall the processes used to answer the adjunct questions to assist them in answering the Terminology Test questions. Therefore, if instructional designers incorporate semantic maps within instructional text in which the learning outcome is knowledge of specific facts, terms, and definitions, they
might consider incorporating adjunct questions and metacognitive process prompts to facilitate the retention of learned information. Of course, this study examined delayed retention after only one week of viewing the instruction, so future research could examine retention of learned material for lengthier periods using these strategies.

For LO2 (the ability to identify parts or positions of an object), regardless of which strategy treatment was used by learners, there was a lack of information decay one week after viewing the instruction. The implication of this finding for instructional designers is that for LO2, embedding only semantic maps into text might be all that is needed to prevent information decay of learned material one week after the instruction is provided. Because neither this study, nor Roshan's (1997) study of different mapping strategies, examined the information decay for LO2 of learners who received only verbal instruction and no semantic maps or other adjunct strategies, future research could be done on this. Besides having implications for instructional design, this finding also has implications for graphic organizer research since it does not support previous graphic organizer research (e.g., Robinson & Schraw, 1994) which found the opposite to be the case and attributed it to learners' reduced processing effort due to computational efficiency (Larkin & Simon, 1987; Waller, 1981). However, it could be that information decay for LO2 did not occur in this study because learners had completed the same Identification Test one week prior to the delayed testing.

For LO3, an interesting occurrence was found. With Strategy 1, information decay of learned material did not occur one week after viewing the instruction. As for Strategy 2, it could not prevent information decay of learned material. Like Strategy 1,
however, Strategy 3 and Strategy 4 were able to prevent the decay of information learned one week after viewing the instruction. Therefore, not only could this finding indicate that embedded semantic maps could be sufficient alone to prevent information decay of learned material one week after viewing the instruction, when the learning outcome is the understanding of complex procedures and processes, but it also could indicate that adjunct questions, intended to complement embedded semantic maps, have an adverse effect on the retention of learned information for LO3. The findings also show that with the addition of metacognitive process prompts to the instruction, this adverse effect on retention is no longer seen for LO3. The adverse effect seen when adjunct questions were added to the semantic maps could again be due to the specific backward or forward processing effects of the adjunct questions (Rickards & Denner, 1978). To reiterate what was described earlier in this chapter, since the adjunct questions used in this study had a tendency to ask students to describe relationships between structures within blood flow processes, subjects could have easily developed a "set" to attend to only this type of information. Attending to only the relevant material, or the material for which the adjunct questions were meant to help process, may have directed learners’ attention away from the other parts of the text passage which were still needed to enhance achievement of LO3. However, as with LO1, the metacognitive process prompts seemed to counteract the negative focusing effect of the adjunct questions. By having learners focus their attention on the processes used to answer the adjunct questions, the metacognitive process prompts could be assisting learners in seeing the larger picture (Lin, 1993) rather than focusing on only the relevant information used to answer the
adjunct questions. Future adjunct question research could incorporate metacognitive process prompts to examine its possible complementary effects with adjunct questions.

Finally, it should be pointed out that the findings which showed a lack of information decay on a particular learning outcome when a specific semantic map treatment was used could very well be due to the rather low mean scores that subjects obtained on the criterion tests during immediate testing. Mean scores ranged from a low of 5.31 (out of a possible 20) on the Comprehension Test to a high of 8.29 (out of a possible 20) on the Terminology Test. Subjects could have lost very little information over a period of week because they had learned little information to begin with. This was also the explanation Canelos (1979) provided for his study. He found that for those strategies which lacked information decay, subjects had "…started with a very small amount of information thus, lost very little" (p. 57). However, for those strategies for which "…students began with a significantly larger amount of information…," subjects "…subsequently lost a significant amount" (p. 57).

**Effect of Strategy Training by Strategy Treatment Used**

It was found that when training on strategies (semantic maps and metacognitive process prompts) was and was not provided to learners, there were no significant differences in achievement for all three learning outcomes--LO1, LO2, and LO3 across the different semantic map treatments. Therefore, neither the training nor the adjunct processing strategies intended to complement the semantic maps, were effective in enhancing the achievement of the three learning outcomes. Possible reasons for this
finding have already been given earlier in this chapter. The discussion for this section will, therefore, focus on the results presented in Table 5.3 and the decay of information for each of the three learning outcomes used in this study.

As was discussed in the previous section, for LO1 (knowledge of specific facts, terms, and definitions), Strategy 1 (semantic maps only) and Strategy 2 (semantic maps and adjunct questions) did not prevent information decay of learned material. However, with the addition of metacognitive process prompts, as found in Strategy 3 and Strategy 4, there was a lack of information decay one week after viewing the instruction. Upon further examination, however, this was only the case when training on semantic maps and metacognitive process prompts was provided to learners. Somewhat surprising, when training was not provided to learners, regardless of the strategy treatment used, information decay did not occur one week after viewing the instruction. In other words, for Strategy 1 and Strategy 2, when training on semantic maps was not provided, there was a lack of information decay; when training on semantic maps was provided, information decay occurred for those who received Strategy 1 and Strategy 2 treatments. Therefore, the implication of these findings for instructional designers who design instruction for LO1 is that design, development, and implementation costs could be saved because it appears that embedded semantic maps need only be used alone, without any provision of training on them, in order for information learned to be retained one week after the instruction.

The negative effect that training on semantic maps appeared to have on the retention of learned material for LO1 could be caused by an insufficient amount of effort
to process and encode the information in the semantic maps. When instructional text lacks structure, learners might more deeply interact with the text. This, in turn, might result in increased encoding of the information (Zimmer, 1985). In this study, it could be that the learners who did not receive training on semantic maps did not understand the structure and function of the semantic maps. Learners who received training on semantic maps learned about the structure and function of the semantic maps and how to interpret them. Learners who did not receive training on the structure and function of the semantic maps might have had to exert more effort to interpret and process the semantic maps and encode the information they contained than learners who received the training. This increased effort might have created a deeper processing of the information contained in the semantic maps, thereby resulting in increased encoding. The more distinctive encoding, or deeper processing, of the information could have allowed for more reliable retrieval of the information (Craik & Lockhart, 1972; Driscoll, 2000), thereby preventing the information decay of learned material for LO1. Learners who received training on semantic maps might not have exerted a sufficient amount of processing effort because they were already familiar with the structure and function of the semantic maps as well as how to interpret them. Therefore, they experienced information decay. However, when learners, who received training on semantic maps, also received the metacognitive process prompts, one of two occurrences might account for the lack of information decay seen with these learners. It could be that the attention learners had to place on how they were processing the information and what they were doing to answer a question (Lin, 1993) could have counteracted the insufficient amount of processing effort that the
semantic map training might have created. Or, as explained earlier in this chapter, subjects who were exposed to the metacognitive process prompts did not engage in recall of the processes used to answer the adjunct questions to assist them in answering the Terminology Test questions until testing was delayed. This could then explain why those who received training on semantic maps and also received embedded metacognitive process prompts did not experience information decay of learned material for LO1.

Previous discussion on LO2 (the ability to identify parts or positions of an object) stated that regardless of the strategy treatment used by learners, there was a lack of information decay one week after viewing the instruction. Further examination showed that this was true for both those who received and those who did not receive training on semantic maps and metacognitive process prompts. As stated in an earlier discussion of LO2 in this chapter, the implication of this finding for instructional designers is that embedding only semantic maps into text might be all that is needed to prevent information decay of learned material one week after the instruction is provided. In addition, the costs associated with training on semantic maps and metacognitive process prompts could be eliminated because training does not appear to be needed when the learning outcome is the ability to identify parts or positions of an object. Not only should the benefits of the strategy be taken into account when determining whether to use it, but the time costs should also be considered (Anderson & Armbruster, 1982).

For LO3 (the understanding of complex processes and procedures), prior discussion on this learning outcome stated that with Strategy 1 (semantic maps only), information decay of learned material did not occur one week after viewing the
instruction. On the other hand, Strategy 2 (semantic maps and adjunct questions) could not prevent information decay of learned material. Like Strategy 1, however, Strategy 3 and Strategy 4 were able to prevent the decay of information learned one week after viewing the instruction. It was explained that the adjunct questions in Strategy 2 could be creating a specific backward or forward processing effect (Rickards & Denner, 1978) that negatively affects retention of learned material for LO3 and that the metacognitive process prompts in Strategy 3 and Strategy 4 could be assisting learners in seeing the larger picture (Lin, 1993) rather than focusing on only the relevant information used to answer the adjunct questions.

Upon further examination of LO3, it was found that when training on semantic maps was provided to learners, Strategy 2 could prevent information decay of learned material one week after viewing the instruction; when training on semantic maps was not provided to learners, Strategy 2 could not prevent information decay. In an earlier discussion on information decay of LO1, it was stated that learners who used Strategy 1 or Strategy 2, and received semantic map training, experienced information decay. The explanation provided was that the semantic map training might have caused an insufficient amount of information processing effort because learners were already familiar with the structure and function of the semantic maps as well as how to interpret them. This, then, creates the question of why training on semantic maps was beneficial to the prevention of information decay for LO3 for those who received semantic maps and adjunct questions yet created an adverse effect on retention of LO1 for those who received semantic maps and adjunct questions. It could be due to the information
contained in the embedded semantic maps and the level of difficulty of the information that must be learned for LO1 and for LO3. For LO1, learners must know terms, facts, and definitions. For LO3, learners must comprehend complex problems and procedures. Therefore, the embedded semantic maps that attempted to enhance the criterion test items for LO1 were focused on facts and terminology while the semantic maps that attempted to enhance the criterion test items for LO3 were focused on procedures. However, displaying procedural information in semantic maps was somewhat difficult, so learners would have had to also refer to the corresponding text to fully comprehend the procedures. It could be that the semantic map training was necessary to assist learners in understanding the complex information found in semantic maps for procedures (LO3), but, at the same time, the semantic map training caused learners to exert less effort on processing the less complex semantic maps for facts, terms, and definitions (LO1).

The purpose of this study was to determine the effects of different adjunct processing strategies in complementing semantic maps embedded within instructional text on student achievement of different types of learning outcomes. Because no significant differences were found on achievement across the treatment groups, it could be concluded that the combination of empirically and theoretically based strategies do not necessarily enhance learning. The effectiveness of such strategies may be realized when used alone. However, when used in combination, the theoretical functions might interact with one another to the point of creating either an innocuous or an adverse effect on
achievement. Therefore, it might not be that the intended learning outcomes of a strategy are faulty but that the learning outcomes have been misapplied. Instructional designers and instructors should, therefore, be wary of the effect that different strategies could have on one another and should take care in the combined application of different strategies, even if the strategies are meant to serve different purposes or target different learning outcomes.

While no significant differences were found across the treatment groups, differences appeared when the retention of learned material within each treatment group was examined. Because information decay for each treatment group varied from one learning outcome to another, the reader should note that the explanations, conclusions, and recommendations for instructional designers and for future research that have been stated in this chapter cannot be generalized across learning outcomes. This, in fact, reiterates not only the importance of conducting research for specific learning outcomes, but also of designing instruction for specific learning outcomes (Hamilton, 1985).

**Limitations**

In this study, students were not compensated for their participation, nor was the instructional content used in the study related to their coursework, so students may have lacked the interest and motivation to fully participate in this study. Students’ performance on the criterion measures may have increased significantly if the instructional content used was relevant to their coursework or major field. Additional class credit given to students who participated in the study could have further increased motivation to fully
participate in responding to and using the embedded strategies and responding to the criterion tests given.

For this study, it must be reiterated that delayed achievement and retention on each of the three learning outcomes, besides being affected by the strategy treatments and training, were most likely also affected by the immediate testing that occurred after subjects viewed the instructional material. To examine a pure delayed achievement of the learning outcomes, additional treatment groups that did not undergo immediate testing and were only administered the delayed testing would be needed.

Finally, the population of this study was Taiwanese undergraduates at a private institute of technology. Semantic maps, metacognitive process prompts, and cognitive feedback were probably quite foreign to the sample taken from this population. In addition, the research cited throughout Chapters 1 through 5 used non-Taiwanese populations. Therefore, caution is advised in generalizing the findings of this study to populations of other countries and cultures.

**Recommendations**

Based on the findings and conclusions of this study, recommendations for future study follow.

1. Replicate the study and utilize other adjunct strategies to complement semantic maps.
2. Replicate the study and vary the duration of delay or use lengthier periods of delay before delayed testing is administered.
3. Replicate the study with this population and incorporate a control group that does not receive any strategies.

4. Incorporate metacognitive process prompts to examine its complementary effects with only adjunct questions and not with both adjunct questions and semantic maps.

5. Replicate the study with different learning outcomes. Differences, particularly in retention of information, may appear with other learning outcomes.

6. Replicate the study with instructional content relevant to participants' coursework, major field, or professional field. This may increase participants' motivation to give their best possible performance on the criterion measures.

7. Replicate the study and incorporate additional treatment groups that only receive delayed testing in order to examine the pure delayed achievement of the learning outcomes.

8. Replicate the study and use different populations (e.g., elementary, high school, or non-Taiwanese).

9. Replicate the study and use delayed review of the instruction. Graphic organizer researchers (e.g., Robinson et al., 1998) have found that significant increases in delayed achievement only appeared when learners were allowed to review the instructional material immediately prior to delayed testing.

10. Replicate the study and pretest for prior knowledge of the subject matter. High and low prior knowledge treatment groups can then be used to determine whether differences appear based on prior knowledge level.

11. Replicate the study and increase the duration of strategy training.
12. Replicate the study and include practice sessions on using the strategies in addition to modeling the use of the strategies.

13. Replicate the study using lengthier text. Researchers (e.g., Holley & Dansereau, 1984) have stated that when passages were less than 2,500 words in length, graphic organizers seemed to have no effect on learning. The text used in this study contained just a little over this given number, so increasing passage length may be necessary to obtain significant results in achievement.

14. Replicate the study and use some means (e.g., class credit or monetary remuneration) to better ensure that participants give their best possible performance on the criterion measures.
BIBLIOGRAPHY


Appendix A

SEMANTIC MAP INTRODUCTION (ENGLISH VERSION)
Introduction to the Instruction

Before you begin this computer module about the structure and function of the human heart, you should know a little about the visuals that you will encounter. These visuals are called *semantic maps*. Here is an example of one:

**Water**
- Boat
- Submarine

**Air**
- Airplane
- Helicopter

**Types of Transportation**

**Land**
- Automobile
- Train
- Bicycle

A semantic map shows different terms, facts, or concepts (in white) that have been grouped into categories (highlighted in yellow). All of the terms or concepts are related to a main or central idea (highlighted in green).

In the instruction on the human heart that you will now begin, you will see semantic maps that show you the relationships between terms, concepts, and ideas about the heart's structure and function.
Appendix B

SEMANTIC MAP INTRODUCTION (CHINESE VERSION)
教學教材簡介

在開始進行這套關於心肌的構造及功能的電腦化教學教材之前，你應該對於你將接觸到的圖表有所了解，這類圖稱為意義圖（semantic maps）。以下是意義圖的一個例子：

義圖將不同的語辭，事實或是概念（
左圖中白色字，例如：“船”，“飛機”
和“火車”），以繪圖為幾個規則（圖中
黃色字，例如：“水路”，“航程”和“
陸路”）的方式呈現出來。所有這些語辭
或概念皆和一個主題或中心思想（圖中
綠色字，例如：“交通運輸的種類”）有關。

在即將開始進行的這套心臟教學教材中，
你會看到一些意義圖，這些圖顯示了一些
與心臟構造及功能有關的語辭，概念及想
法之間的關係。
Appendix C

TREATMENT 1 FOR GROUPS A & B (ENGLISH VERSION)
Introduction to the Instruction

Before you begin this computer module about the structure and function of the human heart, you should know a little about the visuals that you will encounter. These visuals are called semantic maps. Here is an example of one:

A semantic map shows different terms, facts, or concepts (in white) that have been grouped into categories (highlighted in yellow). All of the terms or concepts are related to a main or central idea (highlighted in green).

In the instruction on the human heart that you will now begin, you will see semantic maps that show you the relationships between terms, concepts, and ideas about the heart's structure and function.
The Heart and Its Functions

The human heart is a hollow, bluntly conical, muscular organ. Its pumping action provides the force that circulates the blood through the body. In the average adult, the heart is about five inches long and about two and one half inches thick. A man's heart weighs about eleven ounces and a woman's heart weighs about nine ounces. The heart lies toward the front of the body and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder. The small end of the heart points downward to the front of the chest and toward the left. The lower portion of the heart is called the apex and is the part that you feel beating.

As you read this instruction on the human heart, always imagine that you are viewing not your own heart, but a cross-section of a heart of a person you are facing. Therefore, the right side of your heart will be on the left side of the person you are facing and will be referred to as the left side of the heart in this instruction, while the left side of your heart will be on the right side of the person you are facing and will be referred to as the right side of the heart in this instruction.

To understand the functioning of the heart you will need to be able to identify the parts of the heart. The heart is enclosed in a thin double-walled sac. The layer which forms the outer wall of the sac is called the pericardium. It is composed of a tough, transparent, elastic tissue. It protects the heart from rubbing against the lungs and the walls of the chest. The inner portion of the double-walled sac is called the epicardium. It is attached to the heart muscle.

Here is a semantic map of the heart sac.

- **Layers**
  - Pericardium
  - Epicardium

- **Function**
  - Protects heart

- **Characteristics**
  - Thin
  - Double-walled
  - Tough, transparent, and elastic
  - Attached to the heart muscle
The heart muscle is called the myocardium; it controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. Another feature of the myocardium is that it varies in thickness. For example, the myocardium of the auricle walls (the walls of the upper chambers of the heart) is thinner than the myocardium of the ventricle walls (the walls of the lower chambers of the heart).

Here is a semantic map of the myocardium.

The endocardium is the name given to the inside lining of the heart wall. You can think of the heart as made up of two pumps that circulate blood to all parts of the body. The heart is divided into two halves by the septum. You can think of the two halves as two separate houses with a common wall (the septum) between them.

Each half of the heart is divided into an upper chamber and a lower chamber; the upper chambers are called auricles and the lower chambers are called ventricles. Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously. As was stated previously, the upper chambers on each side of the septum are auricles, and the lower chambers are called ventricles. Auricles have thin walls and act as receiving rooms for the blood while the ventricles below act as pumps, moving the blood away from the heart.

Now imagine a cross-section of a heart of a person you are facing. Blood is entering the right auricle through two veins. Only veins carry blood to the heart. The superior and inferior vena cavae are the two veins which deposit blood in the right auricle. There are no valves at the openings of these veins into the right auricle. The superior vena cava deposits blood into the right auricle from all body parts above heart level, for example, from the head and the arms.

The other vein, the inferior vena cava, deposits blood into the right auricle from the trunk and legs—that is, from regions below the heart level. As blood from the body fills the right auricle, some of it begins to drip into the right ventricle immediately.

Here is a semantic map of the blood flow from the body to the right auricle.
The auricles and ventricles on each side of the heart communicate with each other through openings. The opening between the right auricle and right ventricle is called the tricuspid valve. This valve consists of three triangular flaps of thin, strong, fibrous tissue. These flaps permit the flow of blood into the right ventricle, but prevent it from flowing backward into the right auricle because the ends of the flaps are anchored to the floor of the right ventricle by slender tendons.

The three flaps act like swinging doors which open only in one direction. Thus, blood passes from the right auricle through the tricuspid valve, and into the right ventricle. As soon as the right ventricle is filled with blood, both ventricles begin to contract.

The first effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve.

While the blood pressure behind the flaps brings the flaps together and prevents the flow of blood, the contraction of the right ventricle continues until the blood presses hard enough to open the pulmonary valve and to force the blood into the pulmonary artery. The pulmonary valve is located between the right ventricle and the pulmonary artery.

Here is a semantic map of the blood flow from the right ventricle to the pulmonary artery.
The pulmonary valve, like the tricuspid valve, consists of three flaps which fill with blood backing up in the pulmonary artery. As soon as the right ventricle begins to relax from its contraction, the pulmonary valve prevents blood from flowing back into the right ventricle from the pulmonary artery. The pulmonary valve opens only when the pressure in the right ventricle is greater than the pre-sure in the pulmonary artery, forcing the blood into the pulmonary artery.

The pulmonary valve is composed of flaps or pockets, which the swollen pulmonary artery quickly fills with blood as soon as the right ventricle begins to relax from its contraction. The flaps or pockets of the valve are thus pressed together, and no blood flows back into the right ventricle.

After the blood passes through the pulmonary valve it enters the pulmonary artery, from which it is carried up through the heart to both the left and right lungs. Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle.

Here is a semantic map of the blood flow from the lungs to the left auricle.

**Blood Flow from Lungs to Left Auricle**

**Structures Involved**
- Lungs
- 4 pulmonary veins
- Left auricle

---

Like the right auricle, the left auricle also contracts when it is full, squeezing blood through the mitral valve into the left ventricle. The mitral valve is located between the left auricle and the left ventricle.

Here is a semantic map of the blood flow from the left auricle to the left ventricle.

**Blood Flow from Left Auricle to Left Ventricle**

**Structures Involved**
- Left auricle
- Mitral valve
- Left ventricle
The mitral valve is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the mitral valve, thereby closing the path back to the left auricle.

The contraction of the left ventricle pumps the blood through the entire body. For this reason it is the largest, strongest, and most muscular section of the heart. When the left ventricle (which is filled with blood) contracts, the resulting pressure in the left ventricle opens the aortic valve located in the mouth of the aorta. The aorta is the large artery which carries the blood from the left ventricle.

Here is a semantic map of the left ventricle.

The Circulation of the Blood

The directional flow of blood in the heart is determined by valves which allow the blood to flow in only one direction. Both auricles receive blood simultaneously through unguarded openings in the veins. The right auricle receives its blood through the superior and inferior vena cavae while the left auricle receives its blood through the pulmonary veins.

A wave of muscular contractions starts at the top of the heart and passes downward, simultaneously, over both sides of the heart; that is, both auricles contract at the same time and then relax as the contraction passes down to the ventricles. When the auricles contract, they become small and pale and the blood pressure in their chambers increases, forcing blood through both the tricuspid and mitral valves.

Here is a semantic map of the contractions of the heart.
The instant that the contraction of the auricles has been completed, the ventricles are stimulated to contract; this contraction increases the pressure in the chambers forcing the valves, both the tricuspid and mitral, completely shut.

As the ventricles fill, eddies of the blood float the flaps on both the tricuspid and mitral valves out to a partially closed position. As the ventricle pressure becomes greater than that in the auricles, the (tricuspid and mitral) valves are tightly closed and so prevent blood from being forced backward into the auricles.

While the auricles are relaxing from the contraction, blood flows into them from the veins as the contraction of the ventricles is initiated. The pulmonary valve and the aortic valve, also called the semi-lunar valves, that guard the entrances to the pulmonary artery on the right and the aortic artery on the left are closed by the back pressure provided by blood already in these vessels. When the ventricle pressure becomes greater than that in the exit vessels, the pulmonary and aortic valves open.

Here is a semantic map of the blood flow from the ventricles to the semi-lunar valves.

\[
\text{Causes} \\
\begin{align*}
\text{Pressure increases in ventricles} \\
\text{Pressure in ventricles becomes greater than the pressure in the arteries}
\end{align*}
\]

\text{Effects} \\
\begin{align*}
\text{Tricuspid and mitral valves close} \\
\text{Pulmonary and aortic valves open at the entrance to the pulmonary and aortic arteries}
\end{align*}

Blood flows from the right ventricle into the pulmonary artery en route to the lungs and from the left ventricle into the aorta for distribution through the entire body.

Here is a semantic map of the blood flow away from the heart.

\[
\text{Arteries Used} \\
\begin{align*}
Pulmonary artery \\
Aorta
\end{align*}
\]

\text{Blood Flow Away from the Heart} \\
\begin{align*}
\text{Leaving From} & \quad \text{Going To} \\
\text{Right ventricle} & \quad \text{Lungs} \\
\text{Left ventricle} & \quad \text{Entire body}
\end{align*}

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.

Heart Sac \\
Myocardium \\
Blood Flow from the Body to the Right Auricle \\
Tricuspid Valve \\
Blood Flow from Right Ventricle to Pulmonary Artery \\
Blood Flow from Lungs to Left Auricle \\
Blood Flow from Left Auricle to Left Ventricle \\
Left Ventricle \\
Contractions of the Heart \\
Blood Flow from Ventricles to Semi-Lunar Valves
Immediately following ejection of blood into the arteries, the ventricles begin to relax; this lowers the pressure within their chambers, and the greater pressure in the arteries closes the semi-lunar valves. Pressure within the ventricles is sufficient, however, to maintain closure of the tricuspid and mitral valves against the already increasing auricle pressure.

As the ventricles relax further, pressure within them decreases correspondingly, and the tricuspid and mitral valves are forced open by increased auricle pressure caused by blood flowing into them from the veins. Therefore, before the next auricle contraction, blood is already flowing from the auricles into the ventricles because a greater blood pressure exists in the auricles than in the ventricles.

The Cycle of the Heartbeat Consists of Two Parts

The relaxation of the ventricles, during which they are filled with blood, is called the diastolic phase.

Here is a semantic map of the diastolic phase.

The contraction phase or systolic phase begins when the auricles contract. The blood forces its way through the mitral and tricuspid valves into the ventricles.

Next, the ventricles contract and force the blood through the semi-lunar valves, that is, the pulmonary and aortic valves.

After passing through the pulmonary and aortic valves the blood enters the pulmonary and aortic arteries. The blood leaves the ventricles under terrific pressure and surges through the arteries with a force so great that it bulges their elastic walls. At this point, arterial blood pressure is greatest; this pressure is called the systolic pressure. Then the heart relaxes again and the tricuspid and mitral valves close. Next, blood flows into the auricles; the mitral and tricuspid valves are forced open, and the cycle begins again.

Here is a semantic map of the systolic phase.

This completes the computer instruction on the human heart.

Next, raise your hand to begin a multiple-choice test on the heart. Good luck!
Appendix D

TREATMENT 1 FOR GROUPS A & B (CHINESE VERSION)

Note: To view Appendix D with Adobe Acrobat 4.0 or lower, Asian Language Support (ALS) must be installed. To view with Adobe Acrobat Reader 5.0, go to Adobe's web site at http://www.adobe.com to download the free Traditional Chinese font pack. Adobe also offers a free download of Acrobat Reader in Traditional Chinese available from its web site.
未得到指示前，请勿触碰电脑。
谢谢合作！

心臓
構造及功能
在開始進行這套關於心臟的結構及功能的電腦化教學教材之前，你應該對於你將接觸到的圖示有所了解。這類圖稱為語意圖（semantic maps）。以下是語意圖的一個例子：

語意圖將不同的語詞，事實，或概念（左圖中白色字，例如：“船”，“飛機”和“火車”），以歸納為幾項類別（圖中黃色字，例如：“水路”，“航空”和“陸路”）的方式呈現出來。所有這些語詞或概念皆和一個主題或中心思想（圖中綠色字，例如：“交通運輸的種類”）有關。

在即將開始進行的這套心臟教學教材中，你會看到一些語意圖。這些圖顯示了一些與心臟結構和功能有關的語詞，概念及想法之間的關係。

心臟的構造及功能

心臟是一個中空、圓椎形尖端稍窄的肌肉囊。它藉著壓縮的動作產生力量，使血液在體內循環。成年人的心臟平均約為12.7公分長、6.4公分厚。男人的心臟重量約為312公克，女人的心臟重量約為255公克。心臟位於前胸，位置傾斜，在兩肺之間緊貼於胸骨之下。心臟的底端稱為心尖，此部份即是你能感覺心跳之處。

當你在閱讀這份心臟的教學教材時，試著想像你並非在觀察你自己的心臟，而是以面對面的角度觀察另一個人的心臟。因此，你的心臟的右邊將是在那個面對你的人的左側，並將於以下的說明中指稱為心臟的左側；而你的心臟的左邊將是在那個面對你的人的右側，並將於以下的說明中指稱為心臟的右側。
為了解心臟的運作，你必須能夠確認心臟的分部構造。心臟被包含於一複壁薄囊內。囊的外壁稱為圍心膜，它是由堅韌、透明、且富有彈性的組織形成。圍心膜使心臟免於與肺臟及胸腔壁摩擦。複壁薄囊的內壁稱為心外膜，它貼著心臟的肌肉。

心臟薄囊
- 囲心膜
- 心外膜

特質
- 坚韌、透明、且富有彈性
- 貼著心臟的肌肉

這是心臟薄囊的語意圖。

心臟的肌肉稱為心肌，它控制心臟的收縮與鬆弛。心肌佔心臟的大部份，它的收縮使得血液流動向全身。心肌的另一項特質是它的厚度不一。舉例來說，心房壁（心臟上方腔室之壁）的心肌較心室壁（心臟下方腔室之壁）的心肌薄。

心肌
- 稀薄
- 厚

構成物
- 心房壁
- 心室壁

這是心肌的語意圖。
心臟內襯的膜稱為心內膜。你可以將心臟想象成由兩個幫浦所構成的器官，它將血液循環至身體各部。心隔將心臟垂直分為兩半，你可將這兩半心臟想像成兩間背對背分開的房子，它們之間共有一堵（稱為心隔）。

心臟的左右兩半都分別為上下兩個腔室。心隔兩邊上方的腔室均稱為心房，下方的腔室稱為心室。雖然心臟左右兩邊沒有直接的連接，它們卻是同時作用的。如前所述，上方的兩個腔室稱為心房，下方的兩個腔室稱為心室。心房的壁較薄，它是收集血液之處。心室的壁較厚，它像幫浦一樣作用，將血液輸出心臟。

現在想像你在觀察一個面對著你的人的心臟斷面圖，血液經兩條靜脈進入右心房。只有靜脈才會將血液帶入心臟。上腔靜脈及下腔靜脈是將血液帶入右心房的兩條靜脈，其靜脈開口處沒有瓣膜。上腔靜脈將身體自心臟水平以上各部的血液輸入右心房，譬如：從頭部和手臂。

下腔靜脈將身體自心臟水平以下各區（譬如：脊幹、腿部）的血液輸入右心房。當來自身體各部的血液充滿右心房時，部分的血液開始流入右心室。這是血液從身體流入右心房的語意圖。

同一邊的心房和心室之間有隔口。右心房與右心室之間的隔口稱為三尖瓣，它是由三塊三角形而堅韌的纖維性組織所組成。三尖瓣讓血液流入右心室，卻由於瓣膜尾端有細長的腱繫著在右心室，三尖瓣可阻止血液回流入右心房。這是三尖瓣的語意圖。
三尖瓣就如同一扇只能往一个方向推开的门。因此，血液由右心房，经过三尖瓣，然后流入右心室。当右心室充满血液时，左右心室皆开始收缩产生压力。

首先，右心室所产生压力将使三尖瓣后的血液压力增强。当三尖瓣后面的压力使瓣膜打开，防止右心房及右心室间的血液流通时，右心室继续收缩，直至血液的压力大到足以使肺动脉瓣开放，使血液流入肺动脉。肺动脉瓣位于右心室与肺动脉间。

这是血液从右心室流入肺动脉的意象。

涉及的组织构造
- 三尖瓣
- 右心室
- 肺动脉瓣
- 肺动脉

原因
- 右心室中的压力
- 右心室的收缩

结果
- 三尖瓣关闭
- 肺动脉瓣开放

如欲观看先前的画面，请由下列选一意象，你将看到此图所在的画面。
- 心脏薄囊
- 心肌
- 血液从身体流入右心房
- 三尖瓣

肺动脉瓣是由类似三个片状物组织。当右心室收缩后开始松驰时，肺动脉瓣膜阻止血液由肺动脉倒流入右心室。只有在右心室的的压力大于肺动脉时，肺动脉瓣才会开放，让血液流入肺动脉。

当右心室收缩后开始松驰时，肺动脉瓣膜迅速地充满了从膨胀的肺动脉往后的血液。瓣膜因此而合在一起，血液则无法倒流入右心室。

血液通过肺动脉瓣后流入肺动脉。肺动脉将血液由肺部带入右肺及左肺，血液在肺部清洗及加入氧气。

血液经由四条肺静脉从肺部流回心脏，集中在左心房。

这是血液从肺部流入左心房的意象。

涉及的组织构造
- 肺部
- 四条肺静脉
- 左心房

如欲观看先前的画面，请由下列选一意象，你将看到此图所在的画面。
- 心脏薄囊
- 心肌
- 血液从身体流入右心房
- 三尖瓣
- 血液从右心室流入肺动脉
正如同右心房，當左心房充滿血液時，它開始收縮，壓迫血液從僧帽瓣流入左心室。僧帽瓣位於左心房與左心室之間。這是血液從左心房流入左心室的語意圖。

僧帽瓣的構造類似三尖瓣。當左心室與右心室同時收縮的時候，左心室把血液壓向僧帽瓣的背面，因此也就關閉了通道，使血液無法回流到左心房。

左心室的收縮作用壓縮血液到身體各部。因此，它是整個心臟構造中，體積最大、最強壯、最富肌肉的部份。當左心室在充滿血液時收縮，左心室中所產生的壓力閉啟了位於主動脈開口的主動脈瓣。主動脈是最大的動脈，它從左心室輸送血液到身體各處。

左心室的特性
- 体积最大的心臟構造
- 最强壮的心臓構造
- 最富肌肉的心臓構造

左心室的功能
- 收縮使位於主動脈入口的主動脈瓣開啟
- 輸出血液到身體各部

這是在左心室的語意圖。
血液循環

心臟內部血液流動的方向是由瓣膜控制的。這些瓣膜使得血液只做單向流動。

血液從沒有瓣膜的靜脈開口同時流入左、右心房。右心房由上腔靜脈及下腔靜脈輸入血液，而左心房則由肺靜脈輸入血液。

心臟肌肉收縮的波動
從心臟上端開始，同時移向心室兩邊下端，即是說，左、右心房同時收縮，當收縮轉至心室時，心房即鬆弛。當左、右心房收縮時，其體積變小，變得蒼白，同時其腔室內的血液壓力增加，導致血液通過三角瓣及僧帽瓣。

這是心臟的收縮的語意圖。

當心室充滿血液時，血液的渦流使三尖瓣和僧帽瓣浮起而呈半關閉的狀態。

當心室的壓力持續增強直至大於心房的壓力，心房和心室間的三尖瓣和僧帽瓣則完全關閉，阻止血液流回心房。

心房收縮後即開始鬆弛，血液則由靜脈注入心房，此時心室亦開始收縮。

肺動脈瓣及主動脈瓣，一般又稱為半月瓣。肺動脈瓣是連向右心室，它護衛肺動脈的入口。主動脈瓣連向左心室，護衛進入主動脈的入口。心房收縮之前，因為動脈中原有之血液產生的壓力使得肺動脈瓣及主動脈瓣都是關閉的。當心室收縮的壓力大於動脈內的壓力時，肺動脈瓣及主動脈瓣即開放了。

這是血液從心室流至半月瓣的語意圖。
血液從右心室流入肺動脈，再流入肺部清潔及加入氧氣。同時，血液從左心室流入主動脈輸送到全身。

這是血液從心臟輸出的語意圖。

所使用的動脈
- 肺動脈
- 主動脈

血液從心臟輸出
流入
- 右心室
- 左心室
- 肺部
- 全身各部

離開自
- 心室
- 心房

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到先前所在的畫面。
- 心臓薄囊
- 心肌
- 血液從身體流入右心房
- 三尖瓣
- 血液從右心室流入肺動脈
- 血液從肺部流入左心房
- 血液從左心房流入左心室
- 左心室
- 心臟的收縮
- 血液從心室流入半月瓣

血液流入動脈後，心室立刻開始鬆弛，使腔室內的壓力降低，而動脈的壓力增大，使得半月瓣關閉。然而，儘管心房的壓力開始加大，心室的壓力仍然足以使三尖瓣及僧帽瓣翻開。當心室持續鬆弛下去，腔室內的壓力隨之降低。同時，從靜脈流人的血液增強了心房的壓力，使得三尖瓣及僧帽瓣呈開放狀態。因此，在心房再次收縮前，由於心房的壓力大於心室的壓力，血液已由心房流入了心室。

心跳週期的兩個階段

當心室鬆弛而充滿血液時，此稱為舒張期。這是舒張期的語意圖。
在舒張期，心臟在兩次收縮之間呈鬆弛狀態。血液流入心臟，充滿心房。血液流入心房後，動脈仍保有因上一次心室收縮而產生的部分壓力，這是動脈壓力最低的時候，稱為舒張壓。

另一個階段稱為收縮期，這個階段始於心房收縮。血液因壓力關係透過三尖瓣及僧帽瓣進入心室。然後，心室收縮產生壓力使血液流經半月瓣，也就是肺動脈瓣及主動脈瓣。血液流經肺動脈瓣及主動脈瓣後，進入肺動脈及主動脈。血液在極大的壓力下離開心室，涌動脈。由於產生的壓力很大，以致於使富彈性的動脈壁都膨脹了。在這個時段，動脈血壓是最大的，稱為收縮壓。然後，心臟又開始鬆弛，三尖瓣及僧帽瓣關閉了。接著，血液流入心房，三尖瓣及僧帽瓣受到壓力而張開，這是另一個週期的開始。

這是收縮期的語意圖。

在舒張期，心臟在兩次收縮之間呈鬆弛狀態。血液流入心臟，充滿心房。血液流入心房後，動脈仍保有因上一次心室收縮而產生的部分壓力，這是動脈壓力最低的時候，稱為舒張壓。

另一個階段稱為收縮期，這個階段始於心房收縮。血液因壓力關係透過三尖瓣及僧帽瓣進入心室。然後，心室收縮產生壓力使血液流經半月瓣，也就是肺動脈瓣及主動脈瓣。血液流經肺動脈瓣及主動脈瓣後，進入肺動脈及主動脈。血液在極大的壓力下離開心室，涌動脈。由於產生的壓力很大，以致於使富彈性的動脈壁都膨脹了。在這個時段，動脈血壓是最大的，稱為收縮壓。然後，心臟又開始鬆弛，三尖瓣及僧帽瓣關閉了。接著，血液流入心房，三尖瓣及僧帽瓣受到壓力而張開，這是另一個週期的開始。

這是收縮期的語意圖。

心臟的電腦化教學教材到此結束。

接下來，請舉手告知研究者收回你的心臟教學答案卷並開始作答一份選擇測驗卷。祝你好運！

如欲觀看前面的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。

心房
血液從身體流入右心房
三尖瓣
血液從右心室流入肺動脈
血液從體內流至左心房
左心房
血液從左心房流入左心室
左心室
心臟的收縮
血液從心室流至半月瓣
血液從心室輸出
檢後評

原因

心房收縮
心室收縮

結果

血液受壓經僧帽瓣及三尖瓣流入心室
血液經肺動脈瓣及主動脈瓣流入肺動脈及主動脈

如欲觀看前面的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。

心房
血液從身體流入右心房
三尖瓣
血液從右心室流入肺動脈
血液從體內流至左心房
左心房
血液從左心房流入左心室
左心室
心臟的收縮
血液從心室流至半月瓣
血液從心室輸出
檢後評
Appendix E

TREATMENT 2 FOR GROUPS A & B (ENGLISH VERSION)
The Human Heart

Its Structure and Functions

Introduction to the Instruction

Before you begin this computer module about the structure and function of the human heart, you should know a little about the visuals that you will encounter. These visuals are called semantic maps. Here is an example of one:

A semantic map shows different terms, facts, or concepts (in white) that have been grouped into categories (highlighted in yellow). All of the terms or concepts are related to a main or central idea (highlighted in green).

In the instruction on the human heart that you will now begin, you will see semantic maps that show you the relationships between terms, concepts, and ideas about the heart's structure and function.
The Heart and Its Functions

The human heart is a hollow, bluntly conical, muscular organ. Its pumping action provides the force that circulates the blood through the body. In the average adult, the heart is about five inches long and about two and one half inches thick. A man’s heart weighs about eleven ounces and a woman’s heart weighs about nine ounces. The heart lies toward the front of the body and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder. The small end of the heart points downward to the front of the chest and toward the left. The lower portion of the heart is called the apex and is the part that you feel beating.

As you read this instruction on the human heart, always imagine that you are viewing not your own heart, but a cross-section of a heart of a person you are facing. Therefore, the right side of your heart will be on the left side of the person you are facing and will be referred to as the left side of the heart in this instruction, while the left side of your heart will be on the right side of the person you are facing and will be referred to as the right side of the heart in this instruction.

To understand the functioning of the heart you will need to be able to identify the parts of the heart. The heart is enclosed in a thin double-walled sac. The layer which forms the outer wall of the sac is called the pericardium. It is composed of a tough, transparent, elastic tissue. It protects the heart from rubbing against the lungs and the walls of the chest. The inner portion of the double-walled sac is called the epicardium. It is attached to the heart muscle.

Here is a semantic map of the heart sac.

- **Layers**
  - Pericardium
  - Epicardium

- **Function**
  - Protects heart

- **Heart Sac**

- **Characteristics**
  - Thin
  - Double-walled
  - Tough, transparent, and elastic
  - Attached to the heart muscle
Q1: What is the relationship between the layers of the heart sac and the function of the heart sac?

Write your answer to question 1 (Q1) on the answer sheet you were given. You may view the previous slide by following the directions in the box to the right.

The heart muscle is called the myocardium; it controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. Another feature of the myocardium is that it varies in thickness. For example, the myocardium of the auricle walls (the walls of the upper chambers of the heart) is thinner than the myocardium of the ventricle walls (the walls of the lower chambers of the heart).

Here is a semantic map of the myocardium.

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.
•Heart Sac
Q2: What relationships do you observe between the thickness of the myocardium and the auricles and ventricles?

Write your answer to question 2 (Q2) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The endocardium is the name given to the inside lining of the heart wall.

You can think of the heart as made up of two pumps that circulate blood to all parts of the body. The heart is divided into two halves by the septum. You can think of the two halves as two separate houses with a common wall (the septum) between them.

Each half of the heart is divided into an upper chamber and a lower chamber; the upper chambers are called auricles and the lower chambers are called ventricles. Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously. As was stated previously, the upper chambers on each side of the septum are auricles, and the lower chambers are called ventricles. Auricles have thin walls and act as receiving rooms for the blood while the ventricles below act as pumps, moving the blood away from the heart.

Now imagine a cross-section of a heart of a person you are facing. Blood is entering the right auricle through two veins. Only veins carry blood to the heart. The superior and inferior vena cava are the two veins which deposit blood in the right auricle. There are no valves at the openings of these veins into the right auricle. The superior vena cava deposits blood into the right auricle from all body parts above heart level, for example, from the head and the arms.

The other vein, the inferior vena cava, deposits blood into the right auricle from the trunk and legs—that is, from regions below the heart level. As blood from the body fills the right auricle, some of it begins to drip into the right ventricle immediately.

Here is a semantic map of the blood flow from the body to the right auricle.
Q3: What may be some of the body parts from which the superior and inferior vena cava deposit blood into the right auricle?

Write your answer to question 3 (Q3) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The auricles and ventricles on each side of the heart communicate with each other through openings. The opening between the right auricle and right ventricle is called the tricuspid valve. This valve consists of three triangular flaps of thin, strong, fibrous tissue. These flaps permit the flow of blood into the right ventricle, but prevent it from flowing backward into the right auricle because the ends of the flaps are anchored to the floor of the right ventricle by slender tendons.

Here is a semantic map of the tricuspid valve.
Q4: How do the location and characteristics of the tricuspid valve allow it to function?

Write your answer to question 4 (Q4) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The three flaps act like swinging doors which open only in one direction. Thus, blood passes from the right auricle through the tricuspid valve, and into the right ventricle. As soon as the right ventricle is filled with blood, both ventricles begin to contract.

The first effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve.

While the blood pressure behind the flaps brings the flaps together and prevents the flow of blood, the contraction of the right ventricle continues until the blood presses hard enough to open the pulmonary valve and to force the blood into the pulmonary artery. The pulmonary valve is located between the right ventricle and the pulmonary artery.

Here is a semantic map of the blood flow from the right ventricle to the pulmonary artery.

**Structures Involved**
- Tricuspid valve
- Right ventricle
- Pulmonary valve
- Pulmonary artery

**Blood Flow from Right Ventricle to Pulmonary Artery**

**Causes**
- Pressure in right ventricle
- Contraction of right ventricle

**Effects**
- Tricuspid valve closes
- Pulmonary valve opens
Q5: What does blood pressure have to do with blood flowing from the right ventricle to the pulmonary artery?

Write your answer to question 5 (Q5) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The pulmonary valve, like the tricuspid valve, consists of three flaps which fill with blood backing up in the pulmonary artery. As soon as the right ventricle begins to relax from its contraction, the pulmonary valve prevents blood from flowing back into the right ventricle from the pulmonary artery. The pulmonary valve opens only when the pressure in the right ventricle is greater than the pressure in the pulmonary artery, forcing the blood into the pulmonary artery.

The pulmonary valve is composed of flaps or pockets, which the swollen pulmonary artery quickly fills with blood as soon as the right ventricle begins to relax from its contraction. The flaps or pockets of the valve are thus pressed together, and no blood flows back into the right ventricle.

After the blood passes through the pulmonary valve it enters the pulmonary artery, from which it is carried up through the heart to both the left and right lungs where it is cleansed and oxygenated.

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle.

Here is a semantic map of the blood flow from the lungs to the left auricle.
Q6: How is the flow of blood returning from the lungs to the heart controlled?

Write your answer to question 6 (Q6) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Like the right auricle, the left auricle also contracts when it is full, squeezing blood through the mitral valve into the left ventricle. The mitral valve is located between the left auricle and the left ventricle.

Here is a semantic map of the blood flow from the left auricle to the left ventricle.

Structures Involved
- Left auricle
- Mitral valve
- Left ventricle
The mitral valve is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the mitral valve, thereby closing the path back to the left auricle.

The contraction of the left ventricle pumps the blood through the entire body. For this reason it is the largest, strongest, and most muscular section of the heart. When the left ventricle (which is filled with blood) contracts, the resulting pressure in the left ventricle opens the aortic valve located in the mouth of the aorta. The aorta is the large artery which carries the blood from the left ventricle.

Here is a semantic map of the left ventricle.

Characteristics
- Largest heart section
- Strongest heart section
- Most muscular heart section

Functions
- Contracts to open the aortic valve at the entrance to the aorta
- pumps blood through entire body

The mitral valve is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the mitral valve, thereby closing the path back to the left auricle.

The contraction of the left ventricle pumps the blood through the entire body. For this reason it is the largest, strongest, and most muscular section of the heart. When the left ventricle (which is filled with blood) contracts, the resulting pressure in the left ventricle opens the aortic valve located in the mouth of the aorta. The aorta is the large artery which carries the blood from the left ventricle.

Here is a semantic map of the left ventricle.

Characteristics
- Largest heart section
- Strongest heart section
- Most muscular heart section

Functions
- Contracts to open the aortic valve at the entrance to the aorta
- Pumps blood through entire body
Q8: What may happen if a person’s left ventricle is not as strong as it should be?

Write your answer to question 8 (Q8) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The Circulation of the Blood

The directional flow of blood in the heart is determined by valves which allow the blood to flow in only one direction. Both auricles receive blood simultaneously through unguarded openings in the veins. The right auricle receives its blood through the superior and inferior vena cavae while the left auricle receives its blood through the pulmonary veins.

A wave of muscular contractions starts at the top of the heart and passes downward, simultaneously, over both sides of the heart; that is, both auricles contract at the same time and then relax as the contraction passes down to the ventricles. When the auricles contract, they become small and pale and the blood pressure in their chambers increases, forcing blood through both the tricuspid and mitral valves.

Here is a semantic map of the contractions of the heart.

<table>
<thead>
<tr>
<th>Causes</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both auricles contract</td>
<td>Blood forced through the tricuspid and mitral valves</td>
</tr>
<tr>
<td>Both ventricles contract</td>
<td></td>
</tr>
</tbody>
</table>
Q9: In the semantic map of ‘Contractions of the Heart,’ what is the sequence of the events listed in the map?

Write your answer to question 9 (Q9) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

As the ventricles fill, eddies of the blood float the flaps on both the tricuspid and mitral valves out to a partially closed position. As the ventricle pressure becomes greater than that in the auricles, the (tricuspid and mitral) valves are tightly closed and so prevent blood from being forced backward into the auricles.

While the auricles are relaxing from the contraction, blood flows into them from the veins as the contraction of the ventricles is initiated.

The instant that the contraction of the auricles has been completed, the ventricles are stimulated to contract; this contraction increases the pressure in the chambers forcing the valves, both the tricuspid and mitral, completely shut.

The pulmonary valve and the aortic valve, also called the semi-lunar valves, that guard the entrances to the pulmonary artery on the right and the aortic artery on the left are closed by the back pressure provided by blood already in these vessels. When the ventricle pressure becomes greater than that in the exit vessels, the pulmonary and aortic valves open.

Here is a semantic map of the blood flow from the ventricles to the semi-lunar valves.

**Causes**

- Pressure increases in ventricles
- Pressure in ventricles becomes greater than the pressure in the arteries

**Blood Flow from Ventricles to Semi-Lunar Valves (pulmonary and aortic valves)**

**Effects**

- Tricuspid and mitral valves close
- Pulmonary and aortic valves open at the entrance to the pulmonary and aortic arteries
Q10: As the right ventricle contracts, what happens to the different valves?

Write your answer to question 10 (Q10) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Blood flows from the right ventricle into the pulmonary artery en route to the lungs and from the left ventricle into the aorta for distribution through the entire body.

Here is a semantic map of the blood flow away from the heart.

**Arteries Used**
- Pulmonary artery
- Aorta

**Blood Flow Away from the Heart**

**Leaving From**
- Right ventricle
- Left ventricle

**Going To**
- Lungs
- Entire body
Q11: What relationships do you observe between the type of artery used and the flow of blood away from the heart?

Write your answer to question 11 (Q11) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Immediately following ejection of blood into the arteries, the ventricles begin to relax; this lowers the pressure within their chambers, and the greater pressure in the arteries closes the semi-lunar valves. Pressure within the ventricles is sufficient, however, to maintain closure of the tricuspid and mitral valves against the already increasing auricle pressure.

As the ventricles relax further, pressure within them decreases correspondingly, and the tricuspid and mitral valves are forced open by increased auricle pressure caused by blood flowing into them from the veins. Therefore, before the next auricle contraction, blood is already flowing from the auricles into the ventricles because a greater blood pressure exists in the auricles than in the ventricles.

The Cycle of the Heartbeat Consists of Two Parts

The relaxation of the ventricles, during which they are filled with blood, is called the diastolic phase.

Here is a semantic map of the diastolic phase.
Q12: In the previous slide, in the semantic map of the ‘Diastolic Phase,’ how can it be that “Increased auricle pressure” appears as an event under both ‘Causes’ and ‘Effects’?

Write your answer to question 12 (Q12) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The contraction phase or systolic phase begins when the auricles contract. The blood forces its way through the mitral and tricuspid valves into the ventricles.

Next, the ventricles contract and force the blood through the semi-lunar valves, that is, the pulmonary and aortic valves.

After passing through the pulmonary and aortic valves the blood enters the pulmonary and aortic arteries. The blood leaves the ventricles under terrific pressure and surges through the arteries with a force so great that it bulges their elastic walls. At this point, arterial blood pressure is greatest; this pressure is called the systolic pressure. Then the heart relaxes again and the tricuspid and mitral valves close. Next, blood flows into the auricles; the mitral and tricuspid valves are forced open, and the cycle begins again.

Here is a semantic map of the systolic phase.
Q13: What are some differences and similarities between the diastolic and systolic phases?

Write your answer to question 13 (Q13) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

This completes the computer instruction on the human heart. Next, raise your hand for your answer sheet to be collected and to begin a multiple-choice test on the heart. Good luck!
Appendix F

TREATMENT 2 FOR GROUPS A & B (CHINESE VERSION)

Note: To view Appendix F with Adobe Acrobat 4.0 or lower, Asian Language Support (ALS) must be installed. To view with Adobe Acrobat Reader 5.0, go to Adobe's web site at http://www.adobe.com to download the free Traditional Chinese font pack. Adobe also offers a free download of Acrobat Reader in Traditional Chinese available from its web site.
未得到指示前，
請勿觸碰電腦。
謝謝合作！

心 臟
構造及功能
在開始進行這套關於心臟的構造及功能的電腦化教學教材之前，你應該對於你將接觸到的圖示有所了解。這些圖稱為語意圖（Semantic maps）。以下是語意圖的一個例子：

語意圖將不同的圖辭，事實，或是概念（左圖中白色字，例如：“船”、“飛機”和“火車”），以歸納為幾項類別（圖中黃色字，例如：“水路”、“航空”和“陸路”）的方式呈現出來。所有這些圖辭或概念皆和一個主題或中心思想（圖中綠色字，例如：“交通運輸的種類”）有關。

在即將開始進行的這套心臟教學教材中，你會看到一些語意圖。這些圖顯示了一些與心臟構造及功能有關的語辭，概念及想法之間的關係。

心臟的構造及功能

心臟是一個中空、圓椎形尖端略鈍的肌肉囊。它藉著壓縮的動作產生力量，使血液在體內循環。成年人的心臟平均約為12.7公分長，6.4公分厚。男人的心臟重量約為312公克，女人的心臟重量約為255公克。心臟位於前胸，位置傾斜，心臓的底端偏於胸骨之下。心臓的右側指向右肩，較窄的一端偏向胸部左方。心臓的底端稱為心尖，此部份即是你能感覺心臟之處。

當你在閱讀這份心臟的教學教材時，試著想像你並非在觀察你自己的心臟，而是以面對面的角度觀察另一个人的心臟。因此，你的心臓的右邊將是在那個面對你的人的左側，並將於以下的說明中指稱為心臓的左側；而你的心臓的左邊將是在那個面對你的人的右側，並將於以下的說明中指稱為心臓的右側。
为了了解心脏的运作，你必须能够确认心脏的分部构造。心脏被包含在一复壁薄囊内。囊的外壁称为围心膜，它是由坚韧、透明、且富有弹性的组织形成。围心膜使心脏免於与肺脏及胸腔壁摩擦。复壁薄囊的内壁称为心外膜，它贴著心脏的肌肉。这是心脏薄囊的语意图。

<table>
<thead>
<tr>
<th>薄囊</th>
<th>功能</th>
</tr>
</thead>
<tbody>
<tr>
<td>•围心膜</td>
<td>•保护心脏</td>
</tr>
<tr>
<td>•心外膜</td>
<td></td>
</tr>
</tbody>
</table>

心脏薄囊

- 薄
- 複壁
- 坚韧、透明、且富有弹性
- 贴著心脏的肌肉

这是心脏薄囊的语意图。

问题 1：依据你的观察，心脏薄囊的复壁层和心脏薄囊的功能之间有什么关系？请将问题 1 的答案写在心脏教学答案卷（以下简称为答案卷）上。如果想观看先前的画面，请参照右下角方框内的说明。
心臟的肌肉稱為心肌，它控制心臟的收縮與鬆弛。心肌佔心臟的大部份，它的收縮使得血液流向全身。心肌的另一項特質是它的厚度不一。舉例來說，心房壁（心臟上方腔室之壁）的心肌較心室壁（心臟下方腔室之壁）的心肌薄。

這是心肌的語意圖。

問題 2：依據你的觀察，心肌的厚度以及心房和心室之間有什么關係？

請將問題 2 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
心臟內襯的膜稱為心內膜。

你可以將心臟想成是由兩個幫浦所構成的器官，它將血液循環至身體各部。心隔將心臟垂直分為兩半。你可將這兩半心臟想成是兩間背對背分開的房子，它們之間共有一堵（稱為心隔）。

心臟的左右兩半都分為上下兩個腔室。心隔兩邊的腔室均稱為心房，下方的腔室稱為心室。心隔兩邊上方的腔室均稱為心房，下方的兩個腔室稱為心室。心房的壁較薄，它是收集血液之處。心室的壁較厚，它像幫浦一樣作用，將血液輸出心臟。

現在想像你正在觀察一個面對著你的人的心臟斷面圖，血液經兩條靜脈進入右心房。只有靜脈才會將血液輸入心臟。

心隔兩邊上方的腔室均稱為心房，下方的兩個腔室稱為心室。

上腔靜脈及下腔靜脈是將血液輸入右心房的兩條靜脈，其靜脈開口處沒有瓣膜。上腔靜脈將身體自心臟水平以上各部的血液輸入右心房，譬如：頭部和手臂。

下腔靜脈將身體自心臟水平以下各部（譬如：腿部）的血液輸入右心房。

當來自身體各部的血液充滿右心房時，部分的血液立刻開始注入右心室。

這是血液從身體流入右心房的語意圖。

### 請問 3 : 上腔靜脈和下腔靜脈分別將身體哪些可能的部份的血液輸入右心房？

請告訴你問題的答案寫在答案卷上。如果你想觀看先前的畫面，請參照左側方塊內的說明。

- 血液從心臟水平以上的各部輸入
- 血液從心臟水平以下的各部輸入
同一邊的心房和心室之間有開口。右心房與右心室之間的開口稱為三尖瓣，它是由三塊三角形薄而堅韌的纖維性組織所組成。三尖瓣讓血液流入右心室，卻由於瓣膜尾端有細長的腱繫著在右心室，三尖瓣可阻止血液回流入右心房。

這是三尖瓣的語意圖。

<table>
<thead>
<tr>
<th>位置</th>
<th>特質</th>
</tr>
</thead>
<tbody>
<tr>
<td>介於右心房和右心室之間</td>
<td>三塊三角形的瓣膜</td>
</tr>
<tr>
<td></td>
<td>薄而堅韌的纖維性組織</td>
</tr>
</tbody>
</table>

功能
- 容許血液流入右心室
- 阻止血液回流入右心房

問題 4：三尖瓣的位置和特質如何使它發揮它的功能？
請將問題 4 的答案寫在答題卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。
- 心臟薄囊
- 心肌
- 血液從身體流入右心房
- 三尖瓣
三尖瓣就如同一扇只能往一个方向推開的門。因此，血液由右心房，經過三尖瓣，然後流入右心室。當右心室充滿血液時，左右心室皆開始收縮產生壓力。

首先，右心室所產生的壓力將使三尖瓣後的血液壓力增強。

當三尖瓣後面的血液壓力使瓣膜關閉而防止右心房及右心室間的血液流通時，右心室繼續收縮，直至血液的壓力大到足以使肺動脈瓣開啟，並使血液流入肺動脈。肺動脈瓣位於右心室與肺動脈間。

這是血液從右心室流入肺動脈的語意圖。

原因
• 右心室中的壓力
• 右心室的收縮

結果
• 三尖瓣關閉
• 肺動脈瓣開啟

涉及的組織構造
• 三尖瓣
• 右心室
• 肺動脈

問題 5：血液的壓力和血液從右心室流入肺動脈有什麼關係？
請將問題 5 的答案寫在答案卷上。如果你想觀看先前的畫面，請参照右側方塊內的說明。

問題 5 的答案寫在答案卷上。
肺動脈瓣是由類似三尖瓣的三個片狀物組成。當右心室收縮後開始鬆弛時，肺動脈瓣膜阻止血液由肺動脈倒流入右心室。只有在右心室的壓力大於肺動脈時，肺動脈瓣才會開啟，讓血液流入肺動脈。

當右心室收縮後開始鬆弛時，肺動脈瓣膜則迅速地充滿了從膨脹的肺動脈往後流的血液。瓣膜因此而合在一起，血液則無法倒流入右心室。

血液通過肺動脈瓣後流入肺動脈。肺動脈將血液從心臟帶入右肺及左肺，血液在肺部清潔及加入氧氣。

血液經由四條肺靜脈從肺部流回心臟，集中在左心房。

問題 6：血液是如何經由控制而從肺部流回心臟的？

請將問題 6 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
正如同右心房，當左心房充滿血液時，它開始收縮，壓迫血液從僧帽瓣流入左心室。僧帽瓣位於左心房與左心室之間。這是一種血液從左心房流入左心室的結構。

血液從左心房流入左心室

涉及的組織構造
- 左心房
- 僧帽瓣
- 左心室

問題 7：心臟構造的哪一部分和僧帽瓣很相似？為什麼？
請將問題 7 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你看不到此圖所在的畫面。
- 心臟薄囊
- 心肌
- 血液從身體流入右心房
- 三尖瓣
- 血液從右心室流入肺動脈
- 血液從肺部流入左心房
- 血液從左心房流入左心室
僧帽瓣的構造類似三尖瓣。當左心室與右心室同時收縮的時候，左心室把血液壓向僧帽瓣的背面，因此也就關閉了通道，使血液無法回流到左心房。

左心室的收縮作用壓縮血液到身體各部。因此，它是整個心臟構造中，體積最大、最強壯、及最富肌肉的部份。當左心室在充滿血液時收縮，左心室中所產生的壓力開啟了位於主動脈開口的主動脈瓣。主動脈是最大的動脈，它從左心室輸送血液到身體各處。

這是左心室的語意圖。

問題 8: 倘若左心室不夠強壯，有可能發生什麼？
請將問題 8 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。
- 心臟薄囊
- 心肌
- 血液從身體流入右心房
- 三尖瓣
- 血液從右心房流入肺動脈
- 肺動脈
- 血液從肺部流入左心房
- 血液從左心房流入左心室
- 左心室
血液循環

心臟內血液流動的方向是由瓣膜控制的。這些瓣膜使得血液只做單向流動。血液從沒有瓣膜的靜脈開口同時流入左、右心房。右心房由上腔靜脈及下腔靜脈輸入血液，而左心房則由肺靜脈輸入血液。

心臟肌肉收縮的波動從心臟上端開始，同時移向心臟兩邊下端，換言之，左、右心房同時收縮，當心室紓緩時，左、右心房即鬆弛。當左、右心房收縮時，其體積變小、變得蒼白，同時其腔室內的血液壓力增加，導致血液通過三尖瓣及僧帽瓣。

心臟的收縮

<table>
<thead>
<tr>
<th>原因</th>
<th>結果</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 左、右心房收縮</td>
<td>• 血液受壓力而通過三尖瓣及僧帽瓣</td>
</tr>
<tr>
<td>• 左、右心室收縮</td>
<td></td>
</tr>
<tr>
<td>心臟的紓緩</td>
<td></td>
</tr>
</tbody>
</table>

問題 9：在‘心臟的收縮’這個語意圖中所列出的事件，其發生的順序為何？

請將問題 9 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
當心室充滿血液時，血液的渦流使三尖瓣和僧帽瓣浮起而呈半閉閉的狀態。

當心室的壓力持續增強直至大於心房的壓力，心房和心室間的三尖瓣和僧帽瓣則完全關閉，阻止血液流回心房。

心房收縮後即開始鬆弛，血液則由靜脈注入心房，此時心室亦開始收縮。肺動脈瓣及主動脈瓣，一般又稱為半月瓣。肺動脈瓣是連向右心室，它護衛肺動脈的入口。主動脈瓣連向左心室，護衛進入主動脈的入口。心室收縮之前，因為動脈中原有之血液產生的壓力使得肺動脈瓣及主動脈瓣都是關閉的。當心室收縮的壓力變得大於動脈內的壓力時，肺動脈瓣及主動脈瓣即開放了。

這是血液從心室流至半月瓣的語意圖。
血液從右心室流入肺動脈，再流入肺部清潔及加入氧氣。同時，血液從左心室流入主動脈輸送到全身。

血液從心臟輸出所使用的動脈

- 肺動脈
- 主動脈

離開自
- 右心室
- 左心室

流入
- 肺部
- 全身各部

這就是血液從心臟輸出的語意圖。

問題11: 依據你的觀察，所使用的動脈種類和從心臟輸出的血液流動之間的關係是什麼？

請將問題11的答案寫在答案卷上。如果你想覓看先前的畫面，請參照右側方塊內的說明。

如欲覓看先前的畫面：
- 心臟薄囊
- 心肌
- 血液從身體流入右心房
- 三尖瓣
- 血液從右心室流入肺動脈
- 血液從肺部流入左心房
- 血液從左心房流入左心室
- 左心室
- 心律的改變
- 血液從心室流至半月瓣
- 血液從心臟輸出
血液流入動脈後，心室立刻開始鬆弛，使腔室內的壓力降低，而動脈的壓力增大，使得半月瓣關閉。然而，儘管心房的壓力開始加大，心室的壓力仍然足以使三尖瓣及僧帽瓣關閉。

當心室持續鬆弛下去，腔室內的壓力隨之降低。同時，從靜脈流入的血液增強了心房的壓力，使得三尖瓣及僧帽瓣呈開放狀態。因此，在心房再次收縮前，由於心房的壓力大於心室的壓力，血液已由心房流入了心室。

心跳週期的兩個階段

當心室鬆弛而充滿血液時，此稱為舒張期。

這是舒張期的語意圖。

<table>
<thead>
<tr>
<th>原因</th>
<th>結果</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 心室鬆弛</td>
<td>• 增加的心房壓力</td>
</tr>
<tr>
<td>• 增加的動脈壓力</td>
<td>• 半月瓣關閉</td>
</tr>
<tr>
<td>• 增加的心房壓力</td>
<td>• 三尖瓣和僧帽瓣開放</td>
</tr>
<tr>
<td></td>
<td>• 血液流入並充滿心室</td>
</tr>
</tbody>
</table>

問題12: 在前一個畫面，'舒張期'這個語意圖中，為何“增加的心房壓力”這項事件同時列在原因和結果兩個類別之下呢？

請將問題12的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
另一個階段稱為收縮期，這個階段始於心房收縮。血液因壓力關係透過三尖瓣及僧帽瓣進入心室。然後，心室收縮產生壓力使血液流經半月瓣，也就是肺動脈瓣及主動脈瓣。血液流經肺動脈瓣及主動脈瓣後，進入肺動脈及主動脈。血液在極大的壓力下離開心室，進入動脈。由於產生的壓力很大，以致於使富彈性的動脈壁都膨脹了。在這個時段，動脈血壓是最大的，稱為收縮壓。然後，心臟又開始鬆弛，三尖瓣及僧帽瓣關閉了。接著，血液流入心房，三尖瓣及僧帽瓣受到壓力而張開，這又是另一個週期的開始。這是收縮期的語意圖。

在舒張期，心臟在兩次收縮之間呈鬆弛狀態。血液流入心臟，充滿心房。當血液流入心房時，動脈仍保有因上一次心室收縮而產生的部分壓力，這是動脈壓力最低的時候，稱為舒張壓。另一個階段稱為收縮期，這個階段始於心房收縮。血液因壓力關係透過三尖瓣及僧帽瓣進入心室。然後，心室收縮產生壓力使血液流經半月瓣，也就是肺動脈瓣及主動脈瓣。血液流經肺動脈瓣及主動脈瓣後，進入肺動脈及主動脈。血液在極大的壓力下離開心室，進入動脈。由於產生的壓力很大，以致於使富彈性的動脈壁都膨脹了。在這個時段，動脈血壓是最大的，稱為收縮壓。然後，心臟又開始鬆弛，三尖瓣及僧帽瓣關閉了。接著，血液流入心房，三尖瓣及僧帽瓣受到壓力而張開，這又是另一個週期的開始。這是收縮期的語意圖。

問題 13：什麼是舒張期和收縮期的相異處以及相似處？
請將問題 13 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。
• 心臟薄囊
• 心肌
• 血液從身體流入右心房
• 三尖瓣
• 血液從右心室流入肺動脈
• 血液從肺動脈流入左心房
• 左心室
• 血液從左心房流入左心室
• 血液從肺部流入左心房
• 血液從左心房流入左心室
• 三尖瓣
• 血液從左心房流入左心室

心臟的電腦化教學教材到此結束。
接下來，請舉手告知研究者收回你的心臟教學答案卷並開始作答一份選擇測驗卷。祝你好運！
Appendix G

TREATMENT 3 FOR GROUPS A & B (ENGLISH VERSION)
Introduction to the Instruction

Before you begin this computer module about the structure and function of the human heart, you should know a little about the visuals that you will encounter. These visuals are called semantic maps. Here is an example of one:

```
Types of Transportation

Water
• Boat
• Submarine

Air
• Airplane
• Helicopter

Land
• Automobile
• Train
• Bicycle
```

A semantic map shows different terms, facts, or concepts (in white) that have been grouped into categories (highlighted in yellow). All of the terms or concepts are related to a main or central idea (highlighted in green).

In the instruction on the human heart that you will now begin, you will see semantic maps that show you the relationships between terms, concepts, and ideas about the heart's structure and function.
The Heart and Its Functions

The human heart is a hollow, bluntly conical, muscular organ. Its pumping action provides the force that circulates the blood through the body. In the average adult, the heart is about five inches long and about two and one half inches thick. A man’s heart weighs about eleven ounces and a woman’s heart weighs about nine ounces. The heart lies toward the front of the body and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder. The small end of the heart points downward to the front of the chest and toward the left. The lower portion of the heart is called the apex and is the part that you feel beating.

As you read this instruction on the human heart, always imagine that you are viewing not your own heart, but a cross-section of a heart of a person you are facing. Therefore, the right side of your heart will be on the left side of the person you are facing and will be referred to as the left side of the heart in this instruction, while the left side of your heart will be on the right side of the person you are facing and will be referred to as the right side of the heart in this instruction.

Layers
• Pericardium
• Epicardium

Characteristics
• Thin
• Double-walled
• Tough, transparent, and elastic
• Attached to the heart muscle

Function
• Protects heart

Here is a semantic map of the heart sac.
Q1: What is the relationship between the layers of the heart sac and the function of the heart sac?

Write your answer to question 1 (Q1) on the answer sheet you were given. You may view the previous slide by following the directions in the box to the right.

Q2: How did you determine the relationship between the heart sac’s layers and function?

Write your answer to question 2 (Q2) on the answer sheet you were given. You may view the previous slide by following the directions in the box to the right.

The heart muscle is called the myocardium; it controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. Another feature of the myocardium is that it varies in thickness. For example, the myocardium of the auricle walls (the walls of the upper chambers of the heart) is thinner than the myocardium of the ventricle walls (the walls of the lower chambers of the heart).

Here is a semantic map of the myocardium.
Q3: What relationships do you observe between the thickness of the myocardium and the auricles and ventricles?

Write your answer to question 3 (Q3) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q4: How did you arrive at an answer to Q3?

Write your answer to question 4 (Q4) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The endocardium is the name given to the inside lining of the heart wall.

You can think of the heart as made up of two pumps that circulate blood to all parts of the body. The heart is divided into two halves by the septum. You can think of the two halves as two separate houses with a common wall (the septum) between them.

Each half of the heart is divided into an upper chamber and a lower chamber; the upper chambers are called auricles and the lower chambers are called ventricles. Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously. As was stated previously, the upper chambers on each side of the septum are auricles, and the lower chambers are called ventricles. Auricles have thin walls and act as receiving rooms for the blood while the ventricles below act as pumps, moving the blood away from the heart.

Now imagine a cross-section of a heart of a person you are facing. Blood is entering the right auricle through two veins. Only veins carry blood to the heart. The superior and inferior vena cava are the two veins which deposit blood in the right auricle. There are no valves at the openings of these veins into the right auricle. The superior vena cava deposits blood into the right auricle from all body parts above heart level, for example, from the head and the arms.

The other vein, the inferior vena cava, deposits blood into the right auricle from the trunk and legs—that is, from regions below the heart level. As blood from the body fills the right auricle, some of it begins to drip into the right ventricle immediately.

Here is a semantic map of the blood flow from the body to the right auricle.
Q5: What may be some of the body parts from which the superior and inferior vena cava deposit blood into the right auricle?

Write your answer to question 5 (Q5) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q6: What helped you to select the body parts you put in your answer to Q5?

Write your answer to question 6 (Q6) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The auricles and ventricles on each side of the heart communicate with each other through openings. The opening between the right auricle and right ventricle is called the tricuspid valve. This valve consists of three triangular flaps of thin, strong, fibrous tissue. These flaps permit the flow of blood into the right ventricle, but prevent it from flowing backward into the right auricle because the ends of the flaps are anchored to the floor of the right ventricle by slender tendons.

Here is a semantic map of the tricuspid valve.
Q7: How do the location and characteristics of the tricuspid valve allow it to function?

The three flaps act like swinging doors which open only in one direction. Thus, blood passes from the right auricle through the tricuspid valve, and into the right ventricle. As soon as the right ventricle is filled with blood, both ventricles begin to contract.

The first effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve.

While the blood pressure behind the flaps brings the flaps together and prevents the flow of blood, the contraction of the right ventricle continues until the blood pressure is high enough to open the pulmonary valve and to force the blood into the pulmonary artery.

The pulmonary valve is located between the right ventricle and the pulmonary artery.

Here is a semantic map of the blood flow from the right ventricle to the pulmonary artery.

- **Causes**
  - Pressure in right ventricle
  - Contraction of right ventricle

- **Effects**
  - Tricuspid valve closes
  - Pulmonary valve opens

- **Structures Involved**
  - Tricuspid valve
  - Right ventricle
  - Pulmonary valve
  - Pulmonary artery
Q9: What does blood pressure have to do with blood flowing from the right ventricle to the pulmonary artery?

Write your answer to question 9 (Q9) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q10: How do you know that your answer to Q9 is correct?

Write your answer to question 10 (Q10) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The pulmonary valve, like the tricuspid valve, consists of three flaps which fill with blood backing up in the pulmonary artery. As soon as the right ventricle begins to relax from its contraction, the pulmonary valve prevents blood from flowing back into the right ventricle from the pulmonary artery. The pulmonary valve opens only when the pressure in the right ventricle is greater than the pressure in the pulmonary artery, forcing the blood into the pulmonary artery.

The pulmonary valve is composed of flaps or pockets, which the swollen pulmonary artery quickly fills with blood as soon as the right ventricle begins to relax from its contraction. The flaps or pockets of the valve are thus pressed together, and no blood flows back into the right ventricle.

After the blood passes through the pulmonary valve it enters the pulmonary artery, from which it is carried up through the heart to both the left and right lungs where it is cleansed and oxygenated.

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle.

Here is a semantic map of the blood flow from the lungs to the left auricle.
Q11: How is the flow of blood returning from the lungs to the heart controlled?
Write your answer to question 11 (Q11) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q12: How did you come up with an answer for Q11?
Write your answer to question 12 (Q12) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.

- Heart Sac
- Myocardium
- Blood Flow from the Body to the Right Auricle
- Tricuspid Valve
- Blood Flow from Right Ventricle to Pulmonary Artery
- Blood Flow from Lungs to Left Auricle

Like the right auricle, the left auricle also contracts when it is full, squeezing blood through the mitral valve into the left ventricle. The mitral valve is located between the left auricle and the left ventricle.

Here is a semantic map of the blood flow from the left auricle to the left ventricle.
Q13: What other structure appears similar to the mitral valve and why?

Write your answer to question 13 (Q13) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q14: How did you find your answer to Q13?

Write your answer to question 14 (Q14) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The mitral valve is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the mitral valve, thereby closing the path back to the left auricle.

The contraction of the left ventricle pumps the blood through the entire body. For this reason it is the largest, strongest, and most muscular section of the heart. When the left ventricle (which is filled with blood) contracts, the resulting pressure in the left ventricle opens the aortic valve located in the mouth of the aorta. The aorta is the large artery which carries the blood from the left ventricle.

Here is a semantic map of the left ventricle.

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Characteristics
• Largest heart section
• Strongest heart section
• Most muscular heart section

Functions
• Contracts to open the aortic valve at the entrance to the aorta
• Pumps blood through entire body
Q15: What may happen if a person’s left ventricle is not as strong as it should be?
Write your answer to question 15 (Q15) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q16: What led you to your answer for Q15?
Write your answer to question 16 (Q16) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The Circulation of the Blood

The directional flow of blood in the heart is determined by valves which allow the blood to flow in only one direction.

Both auricles receive blood simultaneously through unguarded openings in the veins. The right auricle receives its blood through the superior and inferior vena cavae while the left auricle receives its blood through the pulmonary veins.

A wave of muscular contractions starts at the top of the heart and passes downward, simultaneously, over both sides of the heart; that is, both auricles contract at the same time and then relax as the contraction passes down to the ventricles. When the auricles contract, they become small and pale and the blood pressure in their chambers increases, forcing blood through both the tricuspid and mitral valves.

Here is a semantic map of the contractions of the heart.
Q17: In the semantic map of ‘Contractions of the Heart,’ what is the sequence of the events listed in the map?

Write your answer to question 17 (Q17) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q18: What helped you figure out the sequence you stated in Q17?

Write your answer to question 18 (Q18) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.
- Heart Sac
- Myocardium
- Blood Flow from the Body to the Right Auricle
- Tricuspid Valve
- Blood Flow from Right Ventricle to Pulmonary Artery
- Blood Flow from Lungs to Left Auricle
- Blood Flow from Left Auricle to Left Ventricle
- Left Ventricle
- Contractions of the Heart

As the ventricles fill, eddies of the blood float the flaps on both the tricuspid and mitral valves out to a partially closed position.

As the ventricle pressure becomes greater than that in the auricles, the (tricuspid and mitral) valves are tightly closed and so prevent blood from being forced backward into the auricles.

While the auricles are relaxing from the contraction, blood flows into them from the veins as the contraction of the ventricles is initiated.

The instant that the contraction of the auricles has been completed, the ventricles are stimulated to contract; this contraction increases the pressure in the chambers forcing the valves, both the tricuspid and mitral, completely shut.

The pulmonary valve and the aortic valve, also called the semi-lunar valves, that guard the entrances to the pulmonary artery on the right and the aortic artery on the left are closed by the back pressure provided by blood already in these vessels. When the ventricle pressure becomes greater than that in the exit vessels, the pulmonary and aortic valves open.

Here is a semantic map of the blood flow from the ventricles to the semi-lunar valves.

**Causes**
- Pressure increases in ventricles
- Pressure in ventricles becomes greater than the pressure in the arteries

**Blood Flow from Ventricles to Semi-Lunar Valves (pulmonary and aortic valves)**

**Effects**
- Tricuspid and mitral valves close
- Pulmonary and aortic valves open at the entrance to the pulmonary and aortic arteries
Q19: As the right ventricle contracts, what happens to the different valves?

Write your answer to question 19 (Q19) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q20: Why do you think your answer to Q19 is correct?

Write your answer to question 20 (Q20) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Blood flows from the right ventricle into the pulmonary artery en route to the lungs and from the left ventricle into the aorta for distribution through the entire body.

Here is a semantic map of the blood flow away from the heart.

**Arteries Used**
- Pulmonary artery
- Aorta

**Blood Flow Away from the Heart**

**Leaving From**
- Right ventricle
- Left ventricle

**Going To**
- Lungs
- Entire body
Q21: What relationships do you observe between the type of artery used and the flow of blood away from the heart?

Write your answer to question 21 (Q21) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q22: How did you determine what the answer should be for Q21?

Write your answer to question 22 (Q22) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Immediately following ejection of blood into the arteries, the ventricles begin to relax; this lowers the pressure within their chambers, and the greater pressure in the arteries closes the semi-lunar valves. Pressure within the ventricles is sufficient, however, to maintain closure of the tricuspid and mitral valves against the already increasing auricle pressure.

As the ventricles relax further, pressure within them decreases correspondingly, and the tricuspid and mitral valves are forced open by increased auricle pressure caused by blood flowing into them from the veins. Therefore, before the next auricle contraction, blood is already flowing from the auricles into the ventricles because a greater blood pressure exists in the auricles than in the ventricles.

The Cycle of the Heartbeat Consists of Two Parts

The relaxation of the ventricles, during which they are filled with blood, is called the diastolic phase.

Here is a semantic map of the diastolic phase.
Q23: In the previous slide, in the semantic map of the 'Diastolic Phase,' how can it be that "Increased auricle pressure" appears as an event under both 'Causes' and 'Effects?'

Write your answer to question 23 (Q23) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q24: Why do you think your answer to Q23 is correct?

Write your answer to question 24 (Q24) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

The heart relaxes between beats in the diastolic phase. Blood flows into the heart filling both auricles. While blood is flowing into the auricles, the recoil of the artery wall still maintains part of the pressure developed by the contraction of the ventricles. This is the time of lowest pressure in the arteries or what is called the diastolic pressure.

The contraction phase or systolic phase begins when the auricles contract. The blood forces its way through the mitral and tricuspid valves into the ventricles.

Next, the ventricles contract and force the blood through the semi-lunar valves, that is, the pulmonary and aortic valves.

After passing through the pulmonary and aortic valves the blood enters the pulmonary and aortic arteries. The blood leaves the ventricles under terrific pressure and surges through the arteries with a force so great that it bulges their elastic walls. At this point, arterial blood pressure is greatest; this pressure is called the systolic pressure. Then the heart relaxes again and the tricuspid and mitral valves close. Next, blood flows into the auricles; the mitral and tricuspid valves are forced open, and the cycle begins again.

Here is a semantic map of the systolic phase.
Q25: What are some differences and similarities between the diastolic and systolic phases?
Write your answer to question 25 (Q25) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q26: How did you come up with your answers to Q25?
Write your answer to question 26 (Q26) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

This completes the computer instruction on the human heart.
Next, raise your hand for your answer sheet to be collected and to begin a multiple-choice test on the heart. Good luck!
Appendix H

TREATMENT 3 FOR GROUPS A & B (CHINESE VERSION)

Note: To view Appendix H with Adobe Acrobat 4.0 or lower, Asian Language Support (ALS) must be installed. To view with Adobe Acrobat Reader 5.0, go to Adobe's web site at http://www.adobe.com to download the free Traditional Chinese font pack. Adobe also offers a free download of Acrobat Reader in Traditional Chinese available from its web site.
未得到指示前，请勿触碰电脑。
谢谢合作！

心　　臟
構造及功能
在開始進行這套關於心臟的構造及功能的電腦化教學教材之前，你應該對於你將接觸到的圖示有所了解。這類圖稱為語意圖 semantic maps。以下是語意圖的一個例子：

語意圖將不同的語辭、事實，或概念（左圖中白色字，例如：“船”、“飛機”和“火車”），以歸納為數項類別（圖中黑色字，例如：“水路”、“航空”和“陸路”）的方式呈現出來。所有這些語辭或概念皆和一個主題或中心思想（圖中綠色字，例如：“交通運輸的種類”）有關。

在即將開始進行的這套心臟教學教材中，你會看到一些語意圖。這些圖顯示了一些與心臟構造和功能有關的語辭、概念及想法之間的關係。

心臟的構造及功能

heart is a hollow, conical, slightly expanded muscular organ. It pumps the blood throughout the body by contracting its muscular walls. In an adult, the heart is approximately 12.7 cm long and 6.4 cm thick. Men’s heart weights about 312 grams, and women’s about 255 grams. It is situated in the thoracic cavity, in a position slightly to the left of the middle line. The bottom of the heart is the left atrium, which is the site of the heart’s pumping action. The right atrium is the right side of the heart, and the left atrium is the left side. The heart’s size is also important in considering the heart’s function.
為了了解心臟的運作，你必須能夠確認心臟的解剖構造。心臟被包裹於一複壁薄囊內。囊的外壁稱為圍心膜，它是由堅韌、透明、且富有彈性的組織形成。圍心膜使心臟免於與肺臟及胸腔壁摩擦。複壁薄囊內壁稱為心外膜，它貼著心臟的肌肉。

這是心臟薄囊的語意圖。

複壁層
- 壁心膜
- 心外膜

心臟薄囊

特質
- 厚
- 複層
- 坚韌、透明、且富有彈性
- 貼著心臟的肌肉

問題 1：依據你的觀察，心臟薄囊的複壁層和心臟薄囊的功能之間有什麼關係？
請將問題 1 的答案寫在心臓教學答案卷（以下簡稱答案卷）上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 2：你是如何判斷心臟薄囊的複壁層和功能之間的關係？
請將問題 2 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
心臟的肌肉稱為心肌，它控制心臟的收縮與鬆弛。心肌佔心臟的大部份，它的收縮使得血液流向全身。心肌的另一項特點是它的厚度不一。例如來說，心房壁（心臟上方腔室之壁）的心肌較心室壁（心臟下方腔室之壁）的心肌薄。這是心肌的語意圖。

問題 3：依據你的觀察，心肌的厚度以及心房和心室之間有什麼關係？請將問題 3 的答案寫在答案卷上。如果想觀看先前的畫面，請參照右側方塊內的說明。

問題 4：你是如何推究出問題 3 的答案？請將問題 4 的答案寫在答案卷上，如果想觀看先前的畫面，請參照右側方塊內的說明。
心臟內襯的膜稱為心內膜。

你可以將心臟想成是由兩個幫浦所構成的器官，它將血液循環至身體各部。你可將這兩個幫浦想成是兩層隔著相隔開的房子，它們之間有一層（稱為心隔）。

心隔的左右兩半都分為上下兩個腔室。心隔兩邊上方的腔室稱為心房，下方的腔室稱為心室。心隔將心臍分成兩半。你可以將這兩半心臍想像成是兩間背對背分開的房子，它們之間有一道隔板（稱為心隔）。

心臍的左右兩半都分為上下兩個腔室。心臍兩邊上方的腔室稱為心房，下方的腔室稱為心室。心臍的壁較厚，它是收集血液之處。心室的壁較薄，它像幫浦一樣作用，將血液輸出心臍。

現在想像你在觀察一個面對著你的人的心臍斷面圖，血液經兩條靜脈進入右心房。只有靜脈才會將血液帶入心臍。上腔靜脈及下腔靜脈是將血液帶入右心房的兩條靜脈。上腔靜脈將身體自心臍水平以上的各部的血液輸入右心房，譬如：從頭部和手臂。

下腔靜脈將身體自心臍水平以下的各部（譬如：腿、腳）的血液輸入右心房。當來自身體各部的血液充滿右心房時，部分的血液立刻開始注入右心室。

這是血液從身體流入右心室的過程。

涉及的組織構造

- 上腔靜脈
- 下腔靜脈

事件

- 血液從心臍水平以上各部輸入
- 血液從心臍水平以下各部輸入

問題 5：上腔靜脈和下腔靜脈分別將身體哪些可能的部份的血液輸入右心房？

請將問題 5 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 6：你依據什麼來選擇身體的部份作為問題 5 答案？

請將問題 6 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
同一邊的心房和心室之間有開口。右心房與右心室之間的開口稱為三尖瓣，它是由三塊三角形薄而堅韌的纖維性組織所組成。三尖瓣讓血液流入右心室，卻由於瓣膜尾端有細長的腱繫著在右心室，三尖瓣可阻止血液回流入右心房。

三尖瓣的語意圖。

問題7：三尖瓣的位置和特質如何使它發揮它的功能？
請將問題7的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題8：你是如何決定問題7的答案？
請將問題7的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
三尖瓣就如同一扇只能往一个方向推開的門。因此，血液由右心房，經過三尖瓣，然後流入右心室。當右心室充滿血液時，左右心室皆開始收縮產生壓力。

首先，右心室所產生的壓力將使三尖瓣後的血液壓力增強。

當三尖瓣後面的血液壓力使瓣膜關閉而防止右心房及右心室間的血液流通時，右心室繼續收縮，直至血液的壓力大到足以使肺動脈瓣開放，並使血液流入肺動脈。肺動脈瓣位於右心室與肺動脈間。

這是血液從右心室流入肺動脈的語意圖。

涉及的組織構造

- 三尖瓣
- 右心室
- 肺動脈瓣
- 肺動脈

血液從右心室流入肺動脈

原因

- 右心室中的壓力
- 右心室的收縮

結果

- 三尖瓣關閉
- 肺動脈瓣開放

問題 9：血液的壓力和血液從右心室流入肺動脈有什麼關係？

請將問題 9 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 10：關於問題 9，你如何判定你的答案是正確的？

請將問題 10 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
肺動脈瓣是由類似三尖瓣的三個片狀物組成。當右心室收縮後開始鬆弛時，肺動脈瓣膜防止血液由肺動脈倒流入右心室。只有在右心室的壓力大於肺動脈時，肺動脈瓣才會開放，讓血液流入肺動脈。

當右心室收縮後開始鬆弛時，肺動脈瓣膜則迅速地充滿了從膨脹的肺動脈後流的血液。瓣膜因此而合在一起，血液則無法倒流入右心室。

血液通過肺動脈瓣後流入肺動脈。肺動脈将血液從心臟帶入右肺及左肺，血液在肺部清潔及加入氧氣。

血液經由四條肺靜脈從肺部流回心臟，集中在左心房。這是血液從肺部流入左心房的語意圖。

問題11: 血液是如何經由控制而從肺部流回心臟的？

問題12: 你是如何推想出問題11的答案？
正如同右心房，當左心房充滿血液時，它開始收縮，壓迫血液從僧帽瓣流入左心室。僧帽瓣位於左心房與左心室之間。這是由血液從左心房流入左心室的示意圖。

血液從左心房流入左心室

涉及的組織構造
- 左心房
- 僧帽瓣
- 左心室

問題13: 心臟構造的哪一部分和僧帽瓣很相似？為什麼？
請將問題13的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題14: 你是如何找出問題13的答案？
請將問題14的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
僧帽瓣的構造類似三尖瓣。當左心室與右心室同時收縮的時候，左心室把血液壓向僧帽瓣的背面，因此也就關閉了通道，使血液無法回流到左心房。

左心室的收縮作用壓縮血液到身體各部。因此，它是整個心臟構造中，體積最大、最強壯及最富肌肉的部份。當左心室在充滿血液時收縮，左心室中所產生的壓力開啟了位於主動脈開口的主動脈瓣。主動脈是最大的動脈，它從左心室輸送血液到身體各處。

這是在心室的語意圖。

### 特質
- 體積最大的心臟構造
- 最強壯的心臟構造
- 最富肌肉的心臟構造

### 功能
- 收縮使位於主動脈入口的主動脈瓣開啟
- 輸出血液到身體各部

問題 15: 倘若左心室不夠強壯，有可能發生什麼？
請將問題 15 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 16: 是什麼引導出你對問題 15 的答案？
請將問題 16 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
血液循環

心臟內部血液流動的方向是由瓣膜控制的。這些瓣膜使得血液只做單向流動。

血液從沒有瓣膜的靜脈開口同時流入左、右心房。右心房由上腔靜脈及下腔靜脈輸入血液，而左心房則由肺靜脈輸入血液。

心臟肌肉收縮的波動從心臟上端開始，同時向心臟兩邊下端，即是說，左、右心房同時收縮，當收縮轉至心室時，心房即鬆弛。當左、右心房收縮時，其體積變小、變得蒼白，同時其腔室內的血液壓力增加，導致血液通過三尖瓣及僧帽瓣。

這是心臟的收縮的語意圖。

原因

- 左、右心房收縮
- 左、右心室收縮
- 心臟的收縮

結果

- 血液受壓力而通過三尖瓣和僧帽瓣

問題17: 在「心臟的收縮」這個語意圖中所列出的事件，其發生的先后順序為何？

請將問題17的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題18: 你根據什麼而得到問題17的答案？

請將問題18的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。
- 心臟薄囊
- 心肌
- 血液從身體流入右心房
- 三尖瓣
- 血液從右心室流入肺動脈
- 血液從肺部流入左心房
- 血液從左心房流入左心室
- 左心室
- 心臟的收縮
當心室充滿血液時，血液的渦流使三尖瓣和僧帽瓣浮起而呈半關閉的狀態。當心室的壓力持續增強直至大於心房的壓力，心房和心室間的三尖瓣和僧帽瓣則完全關閉，阻止血液流入心房。心房收縮後即開始鬆弛，血液則由靜脈注入心房，此時心室亦開始收縮。

心房收縮的瞬間，心室即開始收縮。收縮在心室腔內產生壓力，促使三尖瓣及僧帽瓣完全關閉。

當心室充滿血液時，血液的渦流使三尖瓣和僧帽瓣浮起而呈半關閉的狀態。當心室的壓力持續增強直至大於心房的壓力，心房和心室間的三尖瓣和僧帽瓣則完全關閉，阻止血液流入心房。

心房收縮的瞬間，心室即開始收縮。收縮在心室腔內產生壓力，促使三尖瓣及僧帽瓣完全關閉。

肺動脈瓣及主動脈瓣，一般又稱為半月瓣。肺動脈瓣是連向右心室，它護衛肺動脈的入口。主動脈瓣連向左心室，護衛進入主動脈的入口。心室收縮之前，因為動脈中原存之血液產生的壓力使得肺動脈瓣及主動脈瓣都是關閉的。當心室收縮的壓力變得大於動脈內的壓力時，肺動脈瓣及主動脈瓣即開啟了。

這是血液從心室流至半月瓣的語意圖。

<table>
<thead>
<tr>
<th>原因</th>
</tr>
</thead>
<tbody>
<tr>
<td>心室壓力的增加</td>
</tr>
<tr>
<td>心室壓力大於動脈內的壓力</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>血液從心室流至</th>
</tr>
</thead>
<tbody>
<tr>
<td>半月瓣（肺動脈瓣和主動脈瓣）</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>結果</th>
</tr>
</thead>
<tbody>
<tr>
<td>三尖瓣和僧帽瓣關閉</td>
</tr>
<tr>
<td>肺動脈入口的肺動脈瓣和主動脈入口的主動脈瓣關閉</td>
</tr>
</tbody>
</table>

問題19: 當右心室收縮，不同的瓣膜發生了些什麼事？
請將問題19的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題20: 為什麼你認為你對問題19的答案是正確的？
請將問題20的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。
- 肺動脈瓣
- 至心房
- 血液從身體流入右心房
- 三尖瓣
- 血液從右心房流入肺動脈
- 血液從肺部流入左心房
- 僧帽瓣
- 血液從左心房流入左心室
- 心房
- 血液從左心房流入左心室
血液從右心室流入肺動脈，再流入肺部清潔及加入氧氣。同時，血液從左心室流入主動脈輸送到全身。

這是血液從心臟輸出的語意圖。

血液從心臟輸出

流入

肺

全身各部

離開自

右心室

左心室

所使用的動脈

肺動脈

主動脈

問題 21: 依據你的觀察，所使用的動脈種類和從心臟輸出的血液流動之間的關係是什麼？
請將問題 21 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 22: 你是如何推斷出問題 21 的答案？
請將問題 22 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。

• 心臟薄囊
• 心肌
• 血液從身體流入右心房
• 三尖瓣
• 血液從右心室流入肺動脈
• 血液從肺部流入左心房
• 血液從左心房流入左心室
• 左心室
• 心臟的收縮
• 血液從心室流至半月瓣
• 血液從心臟輸出
血液流入動脈後，心室立刻開始鬆弛，使腔室內的壓力降低，而動脈的壓力增大，使得半月瓣關閉。然而，儘管心房的壓力開始加大，心室的壓力仍然足以使三尖瓣及僞帽瓣關閉。

當心室持續鬆弛下去，腔室內的壓力隨之降低。同時，從靜脈流入的血液增強了心房的壓力，使得三尖瓣及僞帽瓣呈開放狀態。因此，在心房再次收縮前，由於心房的壓力大於心室的壓力，血液已由心房流入了心室。

心跳週期的兩個階段
當心室鬆弛而充滿血液時，此稱為舒張期。這是舒張期的語意圖。

問題23: 在前一個畫面，'舒張期'這個語意圖中，為何“增加的心房壓力”這項事件同時列在“原因”和“結果”兩個類別之下呢？

問題24: 為什麼你認為你對問題23的答案是正確的？
在舒張期，心臟在兩次收縮之間呈舒張狀態。血液流入心臟，充滿心房。當血液流入心房時，動脈仍保有因上一次心室收縮而產生的部分壓力，這是動脈壓力最低的時候，稱為舒張壓。

另一個階段稱為收縮期，這個階段始於心房收縮。血液因壓力關係透過三尖瓣及僧帽瓣進入心室。

然後，心室收縮產生壓力使血液流經半月瓣，也就是肺動脈瓣及主動脈瓣。

血液流經肺動脈瓣及主動脈瓣後，進入肺動脈及主動脈。血液在極大的壓力下離開心室，通往動脈。由於產生的壓力很大，以致於由富有彈性的動脈壁都膨脹了。在這個時段，動脈血流量最大的，稱為收縮期。然後，心臟又開始鬆弛，三尖瓣及僧帽瓣關閉了。接著，血液流入心房，三尖瓣及僧帽瓣受到壓力而張開，這又是另一個週期的開始。

這是收縮期的語意圖。

問題25: 什麼是舒張期和收縮期的相異處以及相似處？
請將問題25的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

在舒張期，心臟在兩次收縮之間呈鬆弛狀態。血液流入心臟，充滿心房。心房收縮，血液因壓力關係透過二尖瓣及低壓的動脈瓣進入心室。然後，心室收縮產生壓力使血液流經半月瓣，也就是肺動脈瓣及主動脈瓣。血液流經肺動脈瓣及主動脈瓣後，進入肺動脈及主動脈，這又是收縮期的語意圖。

問題26: 你是如何推斷出問題25的答案？
請將問題26的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

心臟的電腦化教學教材到此結束。
接下來，請舉手告知研究者收回你的心臟教學答案卷並開始作答一份選擇測驗卷。祝你好運！
Appendix I

TREATMENT 4 FOR GROUPS A & B (ENGLISH VERSION)
Introduction to the Instruction

Before you begin this computer module about the structure and function of the human heart, you should know a little about the visuals that you will encounter. These visuals are called semantic maps. Here is an example of one:

A semantic map shows different terms, facts, or concepts (in white) that have been grouped into categories (highlighted in yellow). All of the terms or concepts are related to a main or central idea (highlighted in green).

In the instruction on the human heart that you will now begin, you will see semantic maps that show you the relationships between terms, concepts, and ideas about the heart's structure and function.
The Heart and Its Functions

The human heart is a hollow, bluntly conical, muscular organ. Its pumping action provides the force that circulates the blood through the body. In the average adult, the heart is about five inches long and about two and one half inches thick. A man's heart weighs about eleven ounces and a woman's heart weighs about nine ounces. The heart lies toward the front of the body and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder. The small end of the heart points downward to the front of the chest and toward the left. The lower portion of the heart is called the apex and is the part that you feel beating.

As you read this instruction on the human heart, always imagine that you are viewing not your own heart, but a cross-section of a heart of a person you are facing. Therefore, the right side of your heart will be on the left side of the person you are facing and will be referred to as the left side of the heart in this instruction, while the left side of your heart will be on the right side of the person you are facing and will be referred to as the right side of the heart in this instruction.

Layers
- Pericardium
- Epicardium

Characteristics
- Thin
- Double-walled
- Tough, transparent, and elastic
- Attached to the heart muscle

Function
- Protects heart

Here is a semantic map of the heart sac.
Q1: What is the relationship between the layers of the heart sac and the function of the heart sac?

Write your answer to question 1 (Q1) on the answer sheet you were given. You may view the previous slide by following the directions in the box to the right.

Q2: How did you determine the relationship between the heart sac’s layers and function?

Write your answer to question 2 (Q2) on the answer sheet you were given. You may view the previous slide by following the directions in the box to the right.

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.

Heart Sac

One way you could have determined the answer for Q1 is by first reviewing the semantic map of the heart sac.

Since Q1 asks for the relationship between the heart sac’s function and layers, you could have looked at those two categories, or nodes, in the semantic map and saw that there are two layers— the pericardium and the epicardium.

Also according to the semantic map, the heart sac protects the heart.

You may have asked yourself, “How might the layers of the heart sac help it to protect the heart?”

To answer this question, notice that there is another node in the semantic map labeled “Characteristics.”

After reviewing the four characteristics of the heart sac found under this category, you see that the heart sac is “double-walled,” or that it has two walls—an inner wall and an outer wall. The outer wall must be the layer that actually protects the heart. However, the semantic map doesn’t tell you which layer of the heart sac is the inner wall and which is the outer wall.

You would have needed to review the reading to find this information.

By doing so, you would have seen that the pericardium is the outer wall and the epicardium is the inner wall. Therefore, the pericardium, the tough outer wall, is the layer of the heart sac that helps to protect the heart.

Layers
- Pericardium
- Epicardium

Function
- Protects heart

Characteristics
- Thin
- Double-walled
- Tough, transparent, and elastic
- Attached to the heart muscle

To understand the functioning of the heart you will need to be able to identify the parts of the heart. The heart is enclosed in a thin double-walled sac. The layer which forms the outer wall of the sac is called the pericardium. It is composed of a tough, transparent, elastic tissue. It protects the heart from rubbing against the lungs and the walls of the chest. The inner portion of the double-walled sac is called the epicardium. It is attached to the heart muscle.
The heart muscle is called the myocardium; it controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. Another feature of the myocardium is that it varies in thickness. For example, the myocardium of the auricle walls (the walls of the upper chambers of the heart) is thinner than the myocardium of the ventricle walls (the walls of the lower chambers of the heart).

Here is a semantic map of the myocardium.

Q3: What relationships do you observe between the thickness of the myocardium and the auricles and ventricles?

Write your answer to question 3 (Q3) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q4: How did you arrive at an answer to Q3?

Write your answer to question 4 (Q4) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.
One way you could have determined the answer for Q3 is by first reviewing the semantic map of the myocardium.

In the myocardium semantic map, you may have noticed that auricles and ventricles are concepts linked to the myocardium.

The map also shows that the characteristics of the myocardium are "Thin" and "Thick.

However, the semantic map doesn't tell you which walls—the auricles or the ventricles—are thin and which are thick. You would have needed to review the reading to find this information.

By doing so, you would have seen that the auricles are the thinner walls and the ventricles are the thicker walls.

The heart muscle is called the myocardium; it controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. Another feature of the myocardium is that it varies in thickness. For example, the myocardium of the auricle walls (the walls of the upper chambers of the heart) is thinner than the myocardium of the ventricle walls (the walls of the lower chambers of the heart).

The endocardium is the name given to the inside lining of the heart wall.

You can think of the heart as made up of two pumps that circulate blood to all parts of the body. The heart is divided into two halves by the septum. You can think of the two halves as two separate houses with a common wall (the septum) between them.

Each half of the heart is divided into an upper chamber and a lower chamber; the upper chambers are called auricles and the lower chambers are called ventricles. Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously. As was stated previously, the upper chambers on each side of the septum are auricles, and the lower chambers are called ventricles. Auricles have thin walls and act as receiving rooms for the blood while the ventricles below act as pumps, moving the blood away from the heart.

Now imagine a cross-section of a heart of a person you are facing. Blood is entering the right auricle through two veins. Only veins carry blood to the heart. The superior and inferior vena cava are the two veins which deposit blood in the right auricle. There are no valves at the openings of these veins into the right auricle. The superior vena cava deposits blood into the right auricle from all body parts above heart level, for example, from the head and the arms.

The other vein, the inferior vena cava, deposits blood into the right auricle from the trunk and legs—that is, from regions below the heart level. As blood from the body fills the right auricle, some of it begins to drip into the right ventricle immediately.

Here is a semantic map of the blood flow from the body to the right auricle.

---

**Blood Flow from the Body to the Right Auricle**

**Structures Involved**
- Superior vena cava
- Inferior vena cava

**Events**
- Blood is deposited from above the heart level
- Blood is deposited from below the heart level
Q5: What may be some of the body parts from which the superior and inferior vena cava deposit blood into the right auricle?

Write your answer to question 5 (Q5) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q6: What helped you to select the body parts you put in your answer to Q5?

Write your answer to question 6 (Q6) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.

- Heart Sac
- Myocardium
- Blood Flow from the Body to the Right Auricle

In order to determine what may be some of the body parts from which the superior and inferior vena cava deposit blood into the right auricle, you would have needed to know which structure is responsible for which event. However, the semantic map doesn’t give you this information. You would have needed to review the reading to find this information.

The reading would tell you that the superior vena cava deposits blood into the right auricle from parts of the body that are above heart level (e.g., the head and arms) while the inferior vena cava deposits blood into the right auricle from parts of the body that are below the heart level (e.g., the trunk and legs).

Again, you could have determined the answer for Q5 by first reviewing the semantic map of the blood flow from the body to the right auricle.

In the semantic map, you may have noticed that the superior and inferior vena cava are the structures involved in the flow of blood from the body to the right auricle.

The map also provides two specific events that occur when blood flows from the body to the right auricle: 1) Blood is deposited from above the level of the heart and 2) Blood is deposited from below the level of the heart.

In order to determine what may be some of the body parts from which the superior and inferior vena cava deposit blood into the right auricle, you would have needed to know which structure is responsible for which event. However, the semantic map doesn’t give you this information. You would have needed to review the reading to find this information.

The reading would tell you that the superior vena cava deposits blood into the right auricle from parts of the body that are above heart level (e.g., the head and arms) while the inferior vena cava deposits blood into the right auricle from parts of the body that are below the heart level (e.g., the trunk and legs).
The auricles and ventricles on each side of the heart communicate with each other through openings. The opening between the right auricle and right ventricle is called the tricuspid valve. This valve consists of three triangular flaps of thin, strong, fibrous tissue. These flaps permit the flow of blood into the right ventricle, but prevent it from flowing backward into the right auricle because the ends of the flaps are anchored to the floor of the right ventricle by slender tendons.

Here is a semantic map of the tricuspid valve.

Q7: How do the location and characteristics of the tricuspid valve allow it to function?

Write your answer to question 7 (Q7) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q8: How did you determine what the answer is for Q7?

Write your answer to question 8 (Q8) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.
One way you could have determined the answer for Q7 is by first examining the question itself. This can give you an indication of how you can proceed to find the answer.

Q7: How do the location and characteristics of the tricuspid valve allow it to function?

Since Q7 asks for how the location and the characteristics of the valve allow it to function, this indicates that both are required for it to function and that maybe there’s a relationship between the two that makes the valve work.

Looking at the ‘Tricuspid Valve’ semantic map, you see that there’s a category labeled ‘Location’ that tells you that the valve is located between the right auricle and the right ventricle.

There’s also a category labeled ‘Characteristics’ that tells you that the valve is strong and fibrous and has three triangular flaps.

Together, this information tells us that there are three flaps between the right auricle and right ventricle that somehow allow the valve to do its job. But you may have asked yourself, “What is its job?”

Again, looking at the semantic map, there’s a category labeled ‘Functions’ that tells you that the tricuspid valve permits blood flow to the right ventricle and prevents blood flow to the right auricle. You may have asked yourself, “How is this information related to what I already know about the tricuspid valve—that it consists of three flaps located between the right auricle and the right ventricle?”

You may have concluded that because the flaps are between the right auricle and the right ventricle, they must be open to allow blood to flow into the right ventricle but close up to prevent blood from flowing back into the right auricle.

The three flaps act like swinging doors which open only in one direction. Thus, blood passes from the right auricle through the tricuspid valve, and into the right ventricle. As so on as the right ventricle is filled with blood, both ventricles begin to contract.

The first effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve.

While the blood pressure behind the flaps brings the flaps together and prevents the flow of blood, the contraction of the right ventricle continues until the blood presses hard enough to open the pulmonary valve and to force the blood into the pulmonary artery. The pulmonary valve is located between the right ventricle and the pulmonary artery.

Here is a semantic map of the blood flow from the right ventricle to the pulmonary artery.

The pulmonary valve is located between the right ventricle and the pulmonary artery.
Q9: What does blood pressure have to do with blood flowing from the right ventricle to the pulmonary artery?

Write your answer to question 9 (Q9) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q10: How do you know that your answer to Q9 is correct?

Write your answer to question 10 (Q10) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

As blood pressure increases in the right ventricle, the tricuspid valve closes and the pulmonary valve opens to allow blood to flow from the right ventricle to the pulmonary artery. A check of your answer to Q9 against the semantic map of Blood Flow from Right Ventricle to Pulmonary Artery may have told you this.

Since Q9 is asking you about the relationship between blood pressure and the flow of blood from the right ventricle to the pulmonary artery, upon examining the semantic map, you may have noticed that the blood flow from the right ventricle to the pulmonary artery is in the center of the map, making it the main idea.

Continuing to examine the map, you may have seen that the only concept that has to do with blood pressure is found under the category labeled, “Causes,” which is linked to the main idea. Therefore, you may have asked yourself, “How is pressure in the right ventricle related to the blood flow from the right ventricle to the pulmonary artery?”

Because pressure in the right ventricle is a “Cause,” it must affect something that has to do with the flow of blood from the right ventricle to the pulmonary artery. In the map, you could have seen that two effects are listed—the tricuspid valve closes and the pulmonary valve opens. However, the map doesn’t tell you how the causes are specifically related to the effects. Therefore, you may have had to review the reading.

From the reading, you could have seen that as blood pressure increases in the right ventricle, the tricuspid valve closes and the pulmonary valve opens to allow blood to flow from the right ventricle to the pulmonary artery.

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.

•Heart Sac
•Myocardium
•Blood Flow from the Body to the Right Auricle
•Tricuspid Valve
•Blood Flow from Right Ventricle to Pulmonary Artery

The first effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve.

While the blood pressure behind the flaps brings the flaps together and prevents the flow of blood, the contraction of the right ventricle continues until the blood presses hard enough to open the pulmonary valve and to force the blood into the pulmonary artery. The pulmonary valve is located between the right ventricle and the pulmonary artery.
The pulmonary valve, like the tricuspid valve, consists of three flaps which fill with blood backing up in the pulmonary artery. As soon as the right ventricle begins to relax from its contraction, the pulmonary valve prevents blood from flowing back into the right ventricle from the pulmonary artery. The pulmonary valve opens only when the pressure in the right ventricle is greater than the pressure in the pulmonary artery, forcing the blood into the pulmonary artery.

The pulmonary valve is composed of flaps or pockets, which the swollen pulmonary artery quickly fills with blood as soon as the right ventricle begins to relax from its contraction. The flaps or pockets of the valve are thus pressed together, and no blood flows back into the right ventricle.

After the blood passes through the pulmonary valve it enters the pulmonary artery, from which it is carried up through the heart to both the left and right lungs where it is cleansed and oxygenated.

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle.

Here is a semantic map of the blood flow from the lungs to the left auricle.

**Blood Flow from Lungs to Left Auricle**

**Structures Involved**
- Lungs
- 4 pulmonary veins
- Left auricle

Q11: How is the flow of blood returning from the lungs to the heart controlled?

Write your answer to question 11 (Q11) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q12: How did you come up with an answer for Q11?

Write your answer to question 12 (Q12) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.
According to the reading, blood flow from the lungs does not appear to be controlled. We may need more information to answer Q11, but one thing we can be sure about is that no valves are controlling the flow of blood from the lungs into the veins and auricles. One way we can tell this is by examining the semantic map of 'Blood Flow from Lungs to Left Auricle.' In this map we do not see any valves listed under the category, 'Structures Involved,' while in other maps, names of valves are listed.

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle. Like the right auricle, the left auricle also contracts when it is full, squeezing blood through the mitral valve into the left ventricle. The mitral valve is located between the left auricle and the left ventricle. Here is a semantic map of the blood flow from the left auricle to the left ventricle.
Q13: What other structure appears similar to the mitral valve and why?
Write your answer to question 13 (Q13) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q14: How did you find your answer to Q13?
Write your answer to question 14 (Q14) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

One way you could have come up with an answer to Q13 is by reviewing what you have read about the mitral valve so far. If you viewed the semantic map of 'Blood Flow from Left Auricle to Left Ventricle,' you would have seen that the mitral valve is one of the structures involved in the flow of blood from the left auricle to the left ventricle. However, in order to determine what other structure it is similar to, we need to know more about the mitral valve. Since the semantic map doesn't tell you anything more about the mitral valve, you would have needed to review the reading.

Like the right auricle, the left auricle also contracts when it is full, squeezing blood through the mitral valve into the left ventricle. The mitral valve is located between the left auricle and the left ventricle.

The reading tells you that the mitral valve is located between the left auricle and the left ventricle and it allows blood to flow from the left auricle to the left ventricle. You may have then asked yourself, "How is this information similar to information about another heart structure?"

You may have reviewed the names of the previous semantic maps and seen that there is another type of valve that you previously learned about—the tricuspid valve. Because the mitral and tricuspid valves are both valves, it would make sense that they may be similar.

If you clicked on the hyperlink to the semantic map of the 'Tricuspid Valve,' you would have seen that it also allows blood to flow from an auricle to a ventricle. The only difference is that the tricuspid valve allows blood to flow from the right auricle to the right ventricle whereas the mitral valve allows blood to flow from the left auricle to the left ventricle.
The mitral valve is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the mitral valve, thereby closing the path back to the left auricle.

The contraction of the left ventricle pumps the blood through the entire body. For this reason it is the largest, strongest, and most muscular section of the heart.

When the left ventricle (which is filled with blood) contracts, the resulting pressure in the left ventricle opens the aortic valve located in the mouth of the aorta. The aorta is the large artery which carries the blood from the left ventricle.

Here is a semantic map of the left ventricle.

Q15: What may happen if a person’s left ventricle is not as strong as it should be?

Write your answer to question 15 (Q15) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q16: What led you to your answer for Q15?

Write your answer to question 16 (Q16) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.
Q15. “What may happen if a person’s left ventricle is not as strong as it should be?,” indicates that the left ventricle should be strong.

This is also indicated in the semantic map of the left ventricle under the category, “Characteristics.”

Upon further examination of the semantic map, you may have noticed that the left ventricle has two functions—contracts to open the aortic valve and pumps blood through the entire body. If the left ventricle is not functioning properly, then one or both of these functions may be affected.

The Circulation of the Blood

The directional flow of blood in the heart is determined by valves which allow the blood to flow in only one direction.

Both auricles receive blood simultaneously through unguarded openings in the veins. The right auricle receives its blood through the superior and inferior vena cavae while the left auricle receives its blood through the pulmonary veins.

A wave of muscular contractions starts at the top of the heart and passes downward, simultaneously, over both sides of the heart; that is, both auricles contract at the same time and then relax as the contraction passes down to the ventricles. When the auricles contract, they become small and pale and the blood pressure in their chambers increases, forcing blood through both the tricuspid and mitral valves.

Here is a semantic map of the contractions of the heart.

Contractions of the Heart

<table>
<thead>
<tr>
<th>Causes</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Both auricles contract</td>
<td>• Blood forced through the tricuspid and mitral valves</td>
</tr>
<tr>
<td>• Both ventricles contract</td>
<td></td>
</tr>
</tbody>
</table>

Left Ventricle

- Characteristics
  - Largest heart section
  - Strongest heart section
  - Most muscular heart section

- Functions
  - Contracts to open the aortic valve at the entrance to the aorta
  - Pumps blood through entire body
Q17: In the semantic map of ‘Contractions of the Heart,’ what is the sequence of the events listed in the map?
Write your answer to question 17 (Q17) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q18: What helped you figure out the sequence you stated in Q17?
Write your answer to question 18 (Q18) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

To view a previous slide:
Click on the name of the semantic map listed below that is found on the slide you want to view.
• Heart Sac
• Myocardium
• Blood Flow from the Body to the Right Auricle
• Tricuspid Valve
• Blood Flow from Right Ventricle to Pulmonary Artery
• Blood Flow from Lungs to Left Auricle
• Blood Flow from Left Auricle to Left Ventricle
• Left Ventricle
• Contractions of the Heart

In order to answer Q17, you would have needed to first review the semantic map of ‘Contractions of the Heart.’ In it, three events are listed under the categories, “Causes” and “Effect.”

However, notice that there are two causes and only one effect. Since we can’t assume that both causes are responsible for the single effect, we still need to review the reading. Also, the semantic map doesn’t tell us about the sequence of these events, so this gives us more reason to review the reading.

Because you already know the events from the semantic map, as you review the reading, look for the sequence of these events that can also help you to determine which cause is responsible for the effect.

By doing this, you could have found that first the auricles contract which forces the blood through the tricuspid and mitral valves, and then the ventricles contract.

Causes
• Both auricles contract
• Both ventricles contract

Effect
• Blood forced through the tricuspid and mitral valves

A wave of muscular contractions starts at the top of the heart and passes downward, simultaneously, over both sides of the heart; that is, both auricles contract at the same time and then relax as the contraction passes down to the ventricles. When the auricles contract, they become small and pale and the blood pressure in their chambers increases, forcing blood through both the tricuspid and mitral valves.
As the ventricles fill, eddies of the blood float the flaps of the tricuspid and mitral valves out to a partially closed position.

As the ventricle pressure becomes greater than that in the atria, the (tricuspid and mitral) valves are tightly closed and so prevent blood from being forced backward into the atria.

While the atria are relaxing from the contraction, blood flows into them from the veins as the contraction of the ventricles is initiated.

The instant that the contraction of the atria has been completed, the ventricles are stimulated to contract; this contraction increases the pressure in the chambers forcing the valves, both the tricuspid and mitral, completely shut.

The pulmonary valve and the aortic valve, also called the semi-lunar valves, that guard the entrances to the pulmonary artery on the right and the aortic artery on the left are closed by the back pressure provided by blood already in these vessels. When the ventricle pressure becomes greater than that in the exit vessels, the pulmonary and aortic valves open.

Here is a semantic map of the blood flow from the ventricles to the semi-lunar valves.

### Causes

- Pressure increases in ventricles
- Pressure in ventricles becomes greater than the pressure in the arteries

### Effects

- Tricuspid and mitral valves close
- Pulmonary and aortic valves open at the entrance to the pulmonary and aortic arteries

Q19: As the right ventricle contracts, what happens to the different valves?

Write your answer to question 19 (Q19) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q20: Why do you think your answer to Q19 is correct?

Write your answer to question 20 (Q20) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.
Blood Flow from Ventricles to Semi-Lunar Valves (pulmonary and aortic valves)

**Causes**
- Pressure increases in ventricles
- Pressure in ventricles becomes greater than the pressure in the arteries

**Effects**
- Tricuspid and mitral valves close
- Pulmonary and aortic valves open at the entrance to the pulmonary and aortic arteries

**Structures Involved**
- Tricuspid valve
- Right ventricle
- Pulmonary valve
- Pulmonary artery

Blood Flow from Right Ventricle to Pulmonary Artery

**Causes**
- Pressure in right ventricle
- Contraction of right ventricle

**Effects**
- Tricuspid valve closes
- Pulmonary valve opens

Arteries Used
- Pulmonary artery
- Aorta

Blood Flow Away from the Heart

Leaving From
- Right ventricle
- Left ventricle

Going To
- Lungs
- Entire body

Blood flows from the right ventricle into the pulmonary artery en route to the lungs and from the left ventricle into the aorta for distribution through the entire body.
Q21: What relationships do you observe between the type of artery used and the flow of blood away from the heart?

Write your answer to question 21 (Q21) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q22: How did you determine what the answer should be for Q21?

Write your answer to question 22 (Q22) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

If you looked at the semantic map of ‘Blood Flow Away from the Heart,’ you could have determined that there are two types of arteries—the pulmonary artery and the aorta.

The semantic map also gives you information about what parts of the heart blood leaves from and where the blood goes to after leaving the heart.

However, since the semantic map doesn’t tell you which of these locations is associated with the pulmonary artery and which is associated with the aorta, you would have needed to look at the reading to find this information.

From the reading, you would have found that where the blood goes to after leaving the heart depends on which artery is used.

Blood that flows to the lungs leaves the heart via the pulmonary artery, while blood that flows to the rest of the body leaves the heart via the aorta.
Immediately following ejection of blood into the arteries, the ventricles begin to relax; this lowers the pressure within their chambers, and the greater pressure in the arteries closes the semi-lunar valves. Pressure within the ventricles is sufficient, however, to maintain closure of the tricuspid and mitral valves against the already increasing auricle pressure.

As the ventricles relax further, pressure within them decreases correspondingly, and the tricuspid and mitral valves are forced open by increased auricle pressure caused by blood flowing into them from the veins. Therefore, before the next auricle contraction, blood is already flowing from the auricles into the ventricles because a greater blood pressure exists in the auricles than in the ventricles.

The Cycle of the Heartbeat Consists of Two Parts

The relaxation of the ventricles, during which they are filled with blood, is called the diastolic phase.

Here is a semantic map of the diastolic phase.

Q23: In the previous slide, in the semantic map of the ‘Diastolic Phase,’ how can it be that “Increased auricle pressure” appears as an event under both ‘Causes’ and ‘Effects’?

Write your answer to question 23 (Q23) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q24: Why do you think your answer to Q23 is correct?

Write your answer to question 24 (Q24) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.
To understand how to answer Q23, you would need to look both at the semantic map of the 'Diastolic Phase' as well as the text or reading.

This is because the semantic map tells you what the causes and effects are, but, like prior semantic maps, it doesn’t tell you which cause is linked to which effect. Therefore, we can’t be certain what the effect is for the cause, “Increased auricle pressure,” and what the cause is for the effect, “Increased auricle pressure.” Because “Increased auricle pressure” is shown in the map as both a cause and an effect, this indicates that something must cause auricle pressure to increase which in turn causes something else to occur.

From the reading, you would find that auricle pressure increases as the ventricles relax. Also, due to the increased auricle pressure, the tricuspid and mitral valves open and the ventricles fill with blood.

Immediately following ejection of blood into the arteries, the ventricles begin to relax; this lowers the pressure within their chambers, and the greater pressure in the arteries closes the semi-lunar valves. Pressure within the ventricles is sufficient, however, to maintain closure of the tricuspid and mitral valves against the already increasing auricle pressure.

As the ventricles relax further, pressure within them decreases correspondingly, and the tricuspid and mitral valves are forced open by increased auricle pressure caused by blood flowing into them from the veins. Therefore, before the next auricle contraction, blood is already flowing from the auricles into the ventricles because a greater blood pressure exists in the auricles than in the ventricles.

The heart relaxes between beats in the diastolic phase. Blood flows into the heart filling both auricles. While blood is flowing into the auricles, the recoil of the artery wall still maintains part of the pressure developed by the contraction of the ventricles. This is the time of lowest pressure in the arteries or what is called the diastolic pressure.

The contraction phase or systolic phase begins when the auricles contract. The blood forces its way through the mitral and tricuspid valves into the ventricles.

Next, the ventricles contract and force the blood through the semi-lunar valves, that is, the pulmonary and aortic valves.

After passing through the pulmonary and aortic valves the blood enters the pulmonary and aortic arteries. The blood leaves the ventricles under terrific pressure and surges through the arteries with a force so great that it bulges their elastic walls. At this point, arterial blood pressure is greatest; this pressure is called the systolic pressure. Then the heart relaxes again and the tricuspid and mitral valves close. Next, blood flows into the auricles; the mitral and tricuspid valves are forced open, and the cycle begins again.

Here is a semantic map of the systolic phase.
Q25: What are some differences and similarities between the diastolic and systolic phases?

Write your answer to question 25 (Q25) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

Q26: How did you come up with your answers to Q25?

Write your answer to question 26 (Q26) on the answer sheet you were given. You may view previous slides by following the directions in the box to the right.

A simple way to quickly search for differences and similarities between the two phases is to look at both the ‘Diastolic Phase’ and ‘Systolic Phase’ semantic maps. By doing this you could have found that in the diastolic phase, the ventricles relax, but in the systolic phase, the ventricles contract.

Another difference is that the pulmonary and aortic valves are closed in the diastolic phase but open in the systolic phase. A similarity is that the tricuspid and mitral valves are open in both the diastolic and systolic phases.

This completes the computer instruction on the human heart. Next, raise your hand for your answer sheet to be collected and to begin a multiple-choice test on the heart. Good luck!
Appendix J

TREATMENT 4 FOR GROUPS A & B (CHINESE VERSION)

Note: To view Appendix J with Adobe Acrobat 4.0 or lower, Asian Language Support (ALS) must be installed. To view with Adobe Acrobat Reader 5.0, go to Adobe's web site at http://www.adobe.com to download the free Traditional Chinese font pack. Adobe also offers a free download of Acrobat Reader in Traditional Chinese available from its web site.
未得到指示前，
請勿觸碰電腦。
謝謝合作！

心 臟
構造及功能
教學教材簡介

在開始進行這套關於心臟的構造及功能的電腦化教學教材之前，你應該對於你將接觸到的圖示有所了解。這類圖稱為語意圖 semantic maps。以下是語意圖的一個例子：

心臟的構造及功能

心臟是一個中空、圓椎形尖端略鈍的肌肉囊。它藉著壓縮的動作產生力量，使血液在體內循環。成年人的心臟平均約為 12.7 公分長、6.4 公分厚。男人的心臟重量約為 312 公克，女人的心臟重量約為 255 公克。心臟位於前胸，位置傾斜，在兩肺之間緊貼於胸骨之下。心臟較寬的一端指向右肩，較窄的一端偏向胸部左方。心臟的底端稱為心尖，此部份即是你能感覺心跳之處。

當你在閱讀這份心臟的教學教材時，試著想像你並非在觀察你自己的心臟，而是以面對面的角度觀察另一個人的心臟。因此，你的心臟的右邊將是在那個面對你的人的左側，並將於以下的說明中指稱為心臟的左側；而你的心臟的左邊將是在那個面對你的人的右側，並將於以下的說明中指稱為心臟的右側。
為了解心臟的運作，你必須能夠確認心臟的分部構造。心臟被包含於一複壁薄囊內。囊的外壁稱為圍心膜，它是由堅韌、透明、且富彈性的組織形成。圍心膜使心臟免於與肺臟及胸腔壁摩擦。複壁薄囊的內壁稱為心外膜，它貼著心臟的肌肉。這便是心臟薄囊的語意圖。

<table>
<thead>
<tr>
<th>特質</th>
<th>功能</th>
</tr>
</thead>
<tbody>
<tr>
<td>薄</td>
<td>保護心臟</td>
</tr>
<tr>
<td>複壁</td>
<td></td>
</tr>
<tr>
<td>堅韌、透明、且富彈性</td>
<td></td>
</tr>
<tr>
<td>貼著心臟的肌肉</td>
<td></td>
</tr>
</tbody>
</table>

問題 1：依據你的觀察，心臟薄囊的複壁層和心臟薄囊的功能之間有什麼關係？
請將問題 1 的答案寫在心臟教學答案卷（以下簡稱答案卷）上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 2：你是如何判斷心臟薄囊的複壁層和功能之間的關係？
請將問題 2 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
一個決定問題的答案的方法是首先檢查心臟薄囊的功能和特質之間的關係。你可以在語意圖中看到這兩個類別。並且可以有兩層，圍心膜和心外膜。

同樣地，根據語意圖，心臟薄囊保護心臟。

你可能會問自己，"心臟薄囊的特質如何幫助保護心臟？" 一個決定問題的答案的方法是首先檢查心臟薄囊的功能。例如，你可能會問自己，"心臟薄囊的特質如何幫助保護心臟？"

檢視過了這類別下所列的四項心臟薄囊的特質後，你會看到心臟薄囊是 "複壁" 的。也就是它有兩層壁，內壁和外壁。這外壁就是實際上保護心臟的那一層。然而，語意圖並沒有告訴你哪一層是心臟薄囊的內壁，哪一層是外壁。你必須再次閱讀正文來找出這項資訊。

為了解心臟的運作，你必須能夠確認心臟的分部構造。心臟被包含於一複壁薄囊內。囊的外壁稱為圍心膜，它是由堅韌、透明、且富彈性的組織形成。圍心膜使心臟免於與肺臟及胸腔壁摩擦。囊的內壁稱為心外膜，它貼著心臟的肌肉。心外膜的特質是你必須確認的。心外膜貼著心臟的肌肉。心外膜的特質是你必須確認的。心外膜貼著心臟的肌肉。
問題 3：依據你的觀察，心肌的厚度以及心房和心室之間有什麼關係？
請將問題 3 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 4：你是如何推究出問題 3 的答案？
請將問題 4 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面：
請由下列選一語意圖，你將看到此圖所在的畫面。
• 心房壁
• 心室壁

一個決定問題 3 答案的方法是首先檢視心肌的語意圖。
你可能注意到在心肌的語意圖中，心房和心室是與心肌相連的兩個概念。
此圖亦顯示心肌的特質包括“薄”與“厚”。
然而，語意圖並未告訴你哪種壁—心房壁或心室壁—是薄而哪種是厚。你必須再次閱讀正文來找出這項資訊。
藉由閱讀正文，你會發現心房壁較薄而心室壁較厚。

心肌

特質
• 薄
• 厚

構成物
• 心房壁
• 心室壁

心臟的肌肉稱為心肌，它控制心臟的收縮與鬆弛。心肌佔心臟的大部份，它的收縮使得血液流向全身。心肌的另一特點是它的厚度不一。換句話說，心房壁（心臟上方腔室之壁）的心肌較心室壁（心臟下方腔室之壁）的心肌薄。
心臟內層的膜稱為心內膜。

你可以將心臟想像是由兩個幫浦所構成的器官，它將血液循環至身體各部。心隔將心臟垂直分為兩半。你可將這兩半心臟想成是兩間背對背分開的房子，它們之間共有一堵（稱為心隔）。

心臟的左右兩半都為上下兩個腔室。心隔兩邊上方的腔室均稱為心房，下方的腔室稱為心室。雖然心臟左右兩邊沒有直接的連繫，它們卻是同時作用的。如前所述，上方的兩個腔室均稱為心房，下方的兩個均稱為心室。心房的壁較薄，它是收集血液之處。心室的壁較厚，它像幫浦一樣作用，將血液輸出心臟。

現在想像你在觀察一個面對著你的人的心臟斷面圖，血液通過兩條靜脈進入右心房。只有靜脈才會將血液帶入心臟。

上腔靜脈及下腔靜脈是將血液帶入右心房的兩條靜脈，其靜脈開口處沒有瓣膜。上腔靜脈将身體自心臟水平以上各部的血液輸入右心房，譬如：從頭部和手臂。

下腔靜脈將身體由心臟水平以下各區（譬如：腸、腿等）的血液輸入右心房。當來自身體各部的血液充滿右心房時，部分的血液立刻開始注入右心室。

這是血液從身體流入右心房的語意圖。

問題 5：上腔靜脈和下腔靜脈分別將身體哪些可能的部份的血液輸入右心房?

請將問題 5 的答案寫在答案卷上。如果想觀看先前的畫面，請參照右側方塊內的說明。

問題 6：你依據什麼來選擇身體的部份作為問題 5 答案?

請將問題 6 的答案寫在答案卷上。如果想觀看先前的畫面，請參照右側方塊內的說明。
### 血液從身體流入右心房

#### 涉及的組織構造
- 上腔靜脈
- 下腔靜脈

#### 事件
- 血液從心臟水平以上的各部輸入
- 血液從心臟水平以下的各部輸入

#### 正文中說明了上腔靜脈和下腔靜脈將身體自心臟水平以上和以下各部位的血液輸入右心房。

#### 三尖瓣的語意圖

<table>
<thead>
<tr>
<th>位置</th>
<th>特質</th>
</tr>
</thead>
</table>
| 介於右心房和右心室之間 | 三塊三角形的瓣膜和竇膜組織
|             | 薄而堅韌的纖維組織
| 三尖瓣     | 三尖瓣

#### 三尖瓣的功能
- 容許血液流入右心室
- 阻止血液回流至右房

#### 同一邊的心房和心室之間有開口。右心房與右心室之間的開口稱為三尖瓣，它是由三塊三角形薄而堅韌的纖維性組織所組成。三尖瓣讓血液流入右心室，即使由於瓣膜尾端有細長的腱繫著在右心室，三尖瓣可阻止血液回流入右心房。
問題 7：三尖瓣的位置和特質如何使它發揮它的功能？

請將問題 7 的答案寫在答案卷上。如果想觀看先前的畫面，請参照右側方塊內的說明。

問題 8：你是如何決定問題 7 的答案？

請將問題 8 的答案寫在答案卷上。如果想觀看先前的畫面，請参照右側方塊內的說明。

一個決定問題 7 答案的方法是從檢視問題本身開始。這能提供你一個如何著手找出答案的指標。

由於問題 7 問三尖瓣的位置和特質如何使它發揮它的功能，此則指出位置和特質兩者皆是三尖瓣發揮其功能所必需的。而且此兩者間可能存在著某種關係使得三尖瓣可以發揮功能。

由三尖瓣的語意圖中，你會看到一個標示為‘位置’的類別。它告訴你這個瓣膜是介於右心房和右心室之間。

另一個標示為‘特質’的類別則告訴你這個瓣膜是堅韌的纖維性組織而且是由三塊三角形的瓣膜所組成。

三尖瓣

位置

• 介於右心房和右心室之間

特質

• 三塊三角形的瓣膜

• 厚而堅韌的纖維性組織

功能

• 容許血液流入右心室

• 阻止血液回流入右心房

結合這些資訊告訴我們介於右心房和右心室之間有三塊瓣膜，由於某種練習使三尖瓣能發揮它的功能。但是你可能問自己，‘什麼是它的功能呢？’

請再看看語意圖，有一個標示為‘功能’的類別說明了三尖瓣容許血液流入右心室以及阻止血液回流入右心房。你可能問自己，‘這項資訊和我所了解的三尖瓣--它是三塊介於右心房和右心室之間的瓣膜所組成--有什麼關係呢？’
三尖瓣就如同一扇只能往一个方向推开的门。因此，血液由右心房，经过三尖瓣，然后流入右心室。当右心室充满血液时，左右心室皆开始收缩产生压力。

首先，右心室所产生得压力将使三尖瓣后方的血液压力增强。

当三尖瓣后方的血液压力使瓣膜关闭而防止右心房及右心室间的血液流通时，右心室继续收缩，直至血液的压力大到足以使肺动脉瓣开放，并使血液流入肺动脉。肺动脉瓣位于右心室与肺动脉间。

这是血液从右心室流入肺动脉的示意图。

问题 9：血液的壓力和血液從右心室流入肺動脈有什麼關係？
請將問題 9 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 10：關於問題 9，你如何判定你的答案是正確的？
請將問題 10 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
當右心室內血液的壓力增強，三尖瓣關閉而肺動脈瓣開啟使血液從右心室流入肺動脈。你可能藉由對照“血液從右心室流入肺動脈”這個語意圖來檢查你的回答而得上述結果。

由於問題9問血液的壓力和血液從右心室流入肺動脈有什麼關係，你可能注意到“血液從右心室流入肺動脈”是在此圖的中心，因此它即是此圖的主題。

繼續檢視此圖，你可能在一個與主題相連而標示為“原因”的類別之下，發現到兩項唯一和血液的壓力有關係的概念。因此，你可能會問自己，“血液從右心室流入肺動脈”是在此圖的中心，因此它即是此圖的主題。

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由於右心室中的壓力是血液從右心室流入肺動脈的唯一原因，它必定影響著血液從右心室流入肺動脈的事物。在此圖中，你可能看到了兩項列出的結果—三尖瓣關閉和肺動脈瓣開啟。然而，此圖並未告訴你這些列出的原因是如何和列出的結果相關。因此，你可能還得參閱正文。

參閱正文，你會看到“血液從右心室流入肺動脈”的壓力增強，三尖瓣關閉而肺動脈瓣開啟使血液從右心室流入肺動脈。肺動脈瓣是由類似三尖瓣的三個片狀物組成。當右心室收縮後開始鬆弛時，肺動脈瓣膜阻止血液由肺動脈倒流入右心室。只有在右心室的壓力大於肺動脈時，肺動脈瓣才會開啟，讓血液流入肺動脈。當右心室收縮後開始鬆弛時，肺動脈瓣膜則迅速地充滿了從膨脹的肺動脈往後流的血液。瓣膜因此而合在一起，血液則無法倒流入右心室。血液通過肺動脈瓣後流入肺動脈。肺動脈脈將血液從心臟帶入右肺及左肺，血液在肺部清潔及加入氧氣後再回到左心房。血液經由四條肺靜脈從肺部流回心臟，集中在左心房。这是血液從肺部流入左心房的語意圖。
問題 11: 血液是如何經由控制而從肺部流回心臟的？
請將問題 11 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 12: 你是如何推想出問題 11 的答案的？
請將問題 12 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

依据正文，從肺部流出的血液似乎並未受到控制。血液經由四條肺靜脈從肺部流回心臟，集中在左心房。血液經由四條肺靜脈從肺部流回心臟，集中在左心房。
正如同右心房，當左心房充滿血液時，它開始收縮，壓迫血液從僧帽瓣流入左心室。僧帽瓣位於左心房與左心室之間。這是由血液從左心房流入左心室的語意圖。

血液從左心房流入左心室

涉及的組織構造
- 左心房
- 僧帽瓣
- 左心室

問題 13: 心臟構造的哪一部分和僧帽瓣很相似？為什麼？
請將問題 13 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 14: 你是如何找出問題 13 的答案？
請將問題 14 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 11: （問題內容）
請將問題 11 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 12: （問題內容）
請將問題 12 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
僧帽瓣的構造類似三尖瓣，當左心室與右心室同時收縮的時候，左心室把血液壓向僧帽瓣的背面，因此也就關閉了通路，使血液無法回流到左心房。左心室的收縮作用壓縮血液到身體各部。因此，它是整體心臟構造中，體積最大、最強壯、及最富肌肉的部份，當左心室在充滿血液時收縮，左心室中所產生的壓力開啓了位於主動脈開口的主動脈瓣，主動脈是最大的動脈，它從左心室輸送血液到身體各處。這都是左心室的語意圖。

僧帽瓣的位置

• 介於左心房和左心室之間

僧帽瓣的特質

• 三塊三角形的瓣膜
• 薄而堅韌的纖維性組織

僧帽瓣的功能

• 容許血液流入左心室
• 阻止血液回流入右心房
問題 15: 倘若左心室不夠強壯，有可能發生什麼？
請將問題 15 的答案寫在答題卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 16: 是什麼引導出你對問題 15 的答案？
請將問題 16 的答案寫在答題卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面，請由下列選一語意圖，你將看到此圖所在的畫面。

- 心臟薄囊
- 心肌
- 血液從身體流入右心房
- 三尖瓣
- 血液從右心室流入肺動脈
- 血液從肺部流入左心房
- 血液從左心房流入左心室
- 左心室

問題 15: "倘若左心室不夠強壯，有可能發生什麼？" 提出了左心室應該是強壯的。

在左心室的語意圖中，"特質" 這個類別之下也列出了這一點。

藉由更深入地審視這個語意圖，你可能注意到左心室有兩項功能：收縮使主動脈瓣開啟及輸出血液到身體各部。如果左心室不能正常運作，那麼左心室的任何一項或者兩項功能都可能受到影響。

特質
- 體積最大的心臟構造
- 最強壯的心臟構造
- 最富肌肉的心臟構造

功能
- 收縮使位於主動脈入口的主動脈瓣開啟
- 輸出血液到身體各部
血液循環

心臟內部血液流動的方向是由瓣膜控制的。這些瓣膜使得血液只做單向流動。

血液從沒有瓣膜的靜脈開口同時流入左、右心房。右心房由上腔靜脈及下腔靜脈輸入血液，而左心房則由肺靜脈輸入血液。

心臟肌肉收縮的波動從心臟上端開始，同時移向心臟兩邊下端。即左、右心房同時收縮，當收縮轉至心室時，心房即鬆弛。當右、左心房收縮時，其體積變小，變得蒼白，同時其腔室內的血液壓力增加，導致血液通過三尖瓣及僧帽瓣。

這是心臟的收縮的語意圖。

問題17: 在‘心臟的收縮’這個語意圖中所列出的事件，其發生的先後順序為何？

請將問題17的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題18: 你根據什麼而得到問題17的答案？

請將問題18的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
為了要回答問題 17, 你可能得先檢視‘心臟的收縮’這個語意圖。此圖中，共有三項事件列於‘原因’和‘結果’兩個類別之下。

然而，請注意有兩項原因卻只有一項結果。因為我們不能假設這兩項原因都會引起這一項結果。我們仍需再次閱讀正文。而且，語意圖並未告訴我們這些事件的先後順序。所以這給我們更充分的理由去參閱正文。

心臟肌肉收縮的波動從心臟上端開始，同時移向心臟兩邊下端，即是說，左、右心房同時收縮，當收縮轉至心室時，心房即鬆弛。當左、右心房收縮時，其體積變小、變得蒼白，同時其腔室內的血液壓力增加，導致血液通過三尖瓣及僧帽瓣。

因為你已從語意圖中知道了這些事件，當你閱讀正文時，尋找這些事件的先後順序將有助於你判斷哪一項原因造成了這項結果。

藉由如此進行，你可能會發現首先左、右心房收縮，因而促成了血液通過三尖瓣和僧帽瓣，然後左、右心室收縮。

當你已閱讀正文時，找到這些事件的順序，你將會發現這是一個非常有幫助的工具。

由心房開始，血液從心房流至半月瓣（肺動脈瓣和主動脈瓣）

原因
• 心室壓力的增加

結果
• 血液從心室流至半月瓣（肺動脈瓣和主動脈瓣）
問題 19: 當右心室收縮，不同的瓣膜發生了些什麼事？
請將問題 19 的答案寫在答案卷上。如果想觀看先前的畫面，請參照右側方塊內的說明。

問題 20: 為什麼你認為你對問題 19 的答案是正確的？
請將問題 20 的答案寫在答案卷上。如果想觀看先前的畫面，請參照右側方塊內的說明。

如欲觀看先前的畫面:
請由下列選一語意圖，你將看
到此圖所在的畫面。
• 心臟壁
• 血液從身體流入右心房
• 三尖瓣
• 血液從右心室流入肺動脈
• 血液從肺部流入左心房
• 肺心室
• 心臟的收縮
• 血液從心室流至半月瓣

你可能藉由觀看“血液從心室流至半月瓣”這個語意圖來嘗試著回答問題 19。
然而，對於回答問題 19 (其著重於右心室)來說，這個圖並不能明確告訴你，當右心室的壓力大於動脈內的壓力時，三尖瓣關閉而肺動脈瓣開啓。因此，你可能試著查看其他針對右心室的圖，像是“血液從右心室流入肺動脈”。這個圖和正文告訴你當右心室收縮，三尖瓣關閉而肺動脈瓣開啓。
血液從右心室流入肺動脈，再流入肺部清潔及加入氧氣。同時，血液從左心室流入主動脈輸送到全身。

這是血液從心臓輸出的語意圖。

問題21: 依據你的觀察，所使用的動脈種類和從心臓輸出的血液流動之間的關係是什麼？
請將問題21的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題22: 你是如何推斷出問題21的答案？
請將問題22的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。
血液從心臟輸出

所使用的動脈
• 肺動脈
• 主動脈

離開自
• 右心室
• 左心室

流入
• 肺部
• 全身各部

從正文中，你會發現血液自心臟離開後所流入的部位是依所使用的動脈而定的。

血液流入動脈後，心室立刻開始鬆弛，使腔室內的壓力降低，而動脈的壓力增大，使得半月瓣關閉。然而，儘管心房的壓力開始加大，心室的壓力仍然足以使得三尖瓣及僧帽瓣關閉。當心室持續鬆弛下去，腔室內的壓力隨之降低。同時，從靜脈流入的血液增強了心房的壓力，使得三尖瓣及僧帽瓣呈開啓狀態。因此，在心房再次收縮前，由於心房的壓力大於心室的壓力，血液已由心房流入了心室。

心跳週期的兩個階段

當心室鬆弛而充滿血液時，此稱為舒張期。這是舒張期的語意圖。

原因
• 心室鬆弛
• 增加的動脈壓力
• 增加的心房壓力

結果
• 增加的心房壓力
• 半月瓣關閉
• 三尖瓣和僧帽瓣開啓
• 血液流入並充滿心室
問題 23: 在前一個畫面，舒張期這個語意圖中，為何“增加的心房壓力”這項事件同時列在原因和結果兩個類別之下呢？

請將問題 23 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

問題 24: 為什麼你認為你對問題 23 的答案是正確的？

請將問題 24 的答案寫在答案卷上。如果你想觀看先前的畫面，請參照右側方塊內的說明。

為瞭解如何回答問題 23，你可能需要觀看“舒張期”這個語意圖以及正文。

這是因為這個語意圖告訴你什麼是原因和結果，但是如同先前的那些語意圖，它並未告訴你哪一項原因和哪一項結果相關。因此，我們並不能確定哪一項結果是由“增加的心房壓力”這個原因所造成的，也不能確定是哪一項原因造成了“增加的心房壓力”這個結果。因為在這個語意圖中，“增加的心房壓力”就是一項原因，又是一項結果，因此某項事件必定造成心房壓力的增加，而此增加的心房壓力接著又導致了其他事件的發生。

從正文中，你將發現當心室鬆弛時，心房的壓力增加。而且，基於增加的心房壓力，三尖瓣和僧帽瓣開啟並心室充滿了血液。

血液流入動脈，心室立刻開始鬆弛，使腔室內的壓力降低，而動脈的壓力增大，使得半月瓣緊閉。然而，心房的壓力開始加大，心室的壓力仍然足以使三尖瓣及僧帽瓣緊閉。

當心室持續鬆弛下去，腔室內的壓力隨之降低。同時，靜脈流入的血液增加了心房的壓力，使得三尖瓣及僧帽瓣呈開放狀態，因此，在心房再收縮前，由於心房的壓力大於心室的壓力，血液已由心房流入了心室。
在舒張期，心臟在兩次收縮之間呈鬆弛狀態。血液流入心臟，充滿心房。當血液流入心房時，動脈瓣仍保有因上次心室收縮而產生的部分壓力，這是動脈壓力最低的時候，稱為舒張期。

另一個階段稱為收縮期，這個階段始於心房收縮。血液因壓力關係透過三尖瓣及僧帽瓣進入心室。

然後，心室收縮產生壓力使血液流經半月瓣，也就是肺動脈瓣及主動脈瓣。

血液流經肺動脈瓣及主動脈後，進入肺動脈及主動脈。血液在極大的壓力下離開心室，進入動脈。由於產生的壓力很大，以致於使血管壁膨脹了。在這個時段，動脈血壓是最大的，稱為收縮壓。

然後，心臟又開始鬆弛，三尖瓣及僧帽瓣關閉了。接著，血液流入心房，三尖瓣及僧帽瓣受到壓力而張開，這又是另一個週期的開始。

這是收縮期的語意圖。

問題 25: 什麼是舒張期和收縮期的相異處以及相似處？請將問題 25 的答案寫在答案卷上。如果你想覓看先前的畫面，請參照右側方塊內的說明。如欲覓看先前的畫面，請由下列選一語意圖，你將看到此圖所在的畫面。

問題 26: 你是如何推斷出問題 25 的答案？請將問題 26 的答案寫在答案卷上。如果你想覓看先前的畫面，請參照右側方塊內的說明。
一個能快速地搜尋這兩個階段的相異處和相似處的簡易方法是查看‘舒張期’和‘收縮期’這兩個語意。如此你會發現在舒張期，心室鬆弛，但在收縮期，心室收縮。

另一個不同點是肺動脈瓣和主動脈瓣在舒張期是關閉的，但在收縮期是開啟的。

一個相似處則是三尖瓣和僧帽瓣在舒張期和收縮期中都是開放的。

<table>
<thead>
<tr>
<th>原因</th>
<th>舒張期</th>
<th>收縮期</th>
</tr>
</thead>
<tbody>
<tr>
<td>執</td>
<td>心室鬆弛</td>
<td>心房收縮</td>
</tr>
<tr>
<td>增加的心房壓力</td>
<td>增加的動脈壓力</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>結果</th>
<th>舒張期</th>
<th>收縮期</th>
</tr>
</thead>
<tbody>
<tr>
<td>增加的心房壓力</td>
<td>半月瓣關閉</td>
<td></td>
</tr>
<tr>
<td>三尖瓣和僧帽瓣關閉</td>
<td>血液流入並充滿心室</td>
<td></td>
</tr>
</tbody>
</table>

血液受壓經僧帽瓣及三尖瓣流入心室
血液經肺動脈瓣及主動脈瓣流入肺動脈及主動脈

心臟的電腦化教學教材到此結束。

接下來，請舉手告知研究者收回你的心臟教學答案卷並開始作答一份選擇測驗卷。祝你好運！
Appendix K

INTRODUCTION TO METACOGNITIVE PROCESS PROMPTS FOR TREATMENTS 3 & 4 IN GROUP B

Note: To view Appendix K with Adobe Acrobat 4.0 or lower, Asian Language Support (ALS) must be installed. To view with Adobe Acrobat Reader 5.0, go to Adobe's web site at http://www.adobe.com to download the free Traditional Chinese font pack. Adobe also offers a free download of Acrobat Reader in Traditional Chinese available from its web site.
Next week, when you go through the computer instruction for the first part of this study, you will be asked some questions about what you are reading. Once you answer a question, the computer will ask a second question about how you got your answer to the first question. This second type of question helps students to better their thinking skills. Here are some examples of this second type of question:

• How did you arrive at an answer to the question?
  (你是如何推究出這個問題的答案？)

• How did you determine what the answer is for the question?
  (你是如何決定這個問題的答案？)

• How did you come up with an answer for the question?
  (你是如何推想出這個問題的答案？)

• How did you find your answer to the question?
  (你是如何找出這個問題的答案？)

• Why do you think your answer to the question is correct?
  (為什麼你認為你對這個問題的答案是正確的？)

In order to respond to questions like the ones above, it helps to ask yourself:

• What did I look at to answer the question and why? An example of an answer to this could be, "I looked at the semantic map because the question asked about the same categories that were found in the semantic map."
  (我察看什麼來回答這個問題？為什麼？一個回答的例子可能是， "我察看這個語意圖，因為可以在這個語意圖中找到這個問題所問及的這兩項類別。"

• What did I specifically look at to answer the question and why? For example, you could have looked at a particular concept or idea or category in the semantic map.
  (我特別地察看什麼來回答這個問題？為什麼？例如，你可以察看在語意圖中的一項特定的概念，觀念或類別。)
• **In what order or sequence did I look at them and why?** An example of an answer to this could be, "I looked at the semantic map but then found out that it didn't provide all the information I needed to answer the question, so I looked at the reading to get the missing information."

(我依照怎樣的順序或次第來察看它們？為什麼？一個回答的例子可能是，“我察看語意圖但發現它並未提供所有回答這個問題所需的資訊，因此我察看正文以獲得所欠缺的資訊。”)

• **What decisions did you make and/or thoughts did you have as you tried to answer the question and why?** An example of an answer to this could be, "First I thought that the answer was X, but as I compared the categories in the semantic map, I realized that the answer was really Y because…"

(當你嘗試回答這個問題時，你作了哪些決定，而且／或者你有哪些想法？一個回答的例子可能是，“首先我認為答案是 X，但是當我比較語意圖中的類別時，我才了解其實答案是 Y，因為…”)


Appendix L

CRITERION TESTS (ENGLISH VERSION)
Part One
IDENTIFICATION TEST

Direction: Select the answer you feel best identified the part of
the heart indicated by the numbered arrows and mark the
Corresponding letter on the provided answer sheet. All
Responses must be made in #2 pencil.

1. Arrow number one (1) points to the
   a. septum
   b. aorta
   c. pulmonary artery
   d. pulmonary vein
   e. none of these

2. Arrow number two (2) points to the
   a. superior vena cava
   b. inferior vena cava
   c. pulmonary artery
   d. tricuspid valve
   e. aorta

3. Arrow number three (3) points to the
   a. right ventricle
   b. right auricle
   c. left ventricle
   d. left auricle
   e. heart muscle

4. Arrow number four (4) points to the
   a. pulmonary valve
   b. pulmonary vein
   c. aortic valve
   d. tricuspid valve
   e. mitral valve

5. Arrow number five (5) points to the
   a. aorta
   b. pulmonary artery
   c. superior vena cava
   d. inferior vena cava
   e. pulmonary vein

6. Arrow number six (6) points to the
   a. aortic valve
   b. pulmonary valve
   c. mitral valve
   d. tricuspid valve
   e. semi-lunar valve

7. Arrow number seven (7) points to the
   a. left ventricle
   b. right ventricle
   c. right auricle
   d. left auricle
   e. vascular space

8. Arrow number eight (8) points to the
   a. myocardium
   b. ectoderm
   c. pericardium
   d. endocardium
   e. epicardium

9. Arrow number nine (9) points to the
   a. endocardium
   b. myocardium
   c. pericardium
   d. ectoderm
   e. septum

10. Arrow number ten (10) points to the
    a. endocardium
    b. myocardium
    c. pericardium
    d. endoderm
    e. aortic base

11. Arrow number eleven (11) points to the
    a. epicardium
    b. pericardium
    c. endocardium
    d. myocardium
    e. none of these

12. Arrow number twelve (12) points to the
    a. pericardium
    b. myocardium
    c. endocardium
    d. endoderm
    e. apex

13. Arrow number thirteen (13) points to the
    a. pericardium
    b. endocardium
    c. ectoderm
    d. endocardium
    e. myocardium

14. Arrow number fourteen (14) points to the
    a. right ventricle
    b. left ventricle
    c. left auricle
    d. right auricle
    e. apex

15. Arrow number fifteen (15) points to the
    a. pulmonary veins
    b. tendons
    c. aortas
    d. pericardium
    e. none of these

16. Arrow number sixteen (16) points to the
    a. venic valve
    b. pulmonary valve
    c. tricuspid valve
    d. mitral valve
    e. aortic valve

17. Arrow number seventeen (17) points to the
    a. superior vena cava
    b. tricuspid valve
    c. aortic valve
    d. pulmonary valve
    e. mitral valve

18. Arrow number eighteen (18) points to the
    a. right auricle
    b. right ventricle
    c. left auricle
    d. left ventricle
    e. semi-lunar chamber
19. Arrow number nineteen (19) points to the
   a. inferior vena cava
   b. superior vena cava
   c. aortas
   d. pulmonary veins
   e. pulmonary arteries

20. Arrow number twenty (20) points to the
    a. inferior vena cava
    b. aorta
    c. pulmonary artery
    d. septum
    e. superior vena cava

---

21. ____ is (are) the thickest walled chamber(s) of the heart.
    a. auricles
d. pericardium
b. myocardium
e. endocardium
    c. ventricles

22. The contraction of the heart occurs during the
    ____ phase.
    a. systolic
d. parasympathetic
b. sympathetic
e. sympathetic
c. diastolic

23. Lowest blood pressure in the arteries occurs during the
    ____ phase.
    a. sympathetic
d. systolic
b. sympathetic
e. parasympathetic
c. diastolic

24. Blood from the right ventricle goes to the lungs through the
    ____.
    a. tricuspid valve
d. pulmonary veins
b. aortic artery
e. superior vena cava
c. pulmonary artery

25. The ____ is (are) the strongest section(s) of the heart.
    a. left ventricle
d. right ventricle
b. aorta
e. tendons
c. septum

26. When blood returns to the heart from the lungs, it enters the
    ____.
    a. left auricle
d. right ventricle
b. pulmonary valve
e. pulmonary artery
c. left ventricle

27. Vessels that allow the blood to flow from the heart are called the
    ____.
    a. veins
d. tendons
b. arteries
e. valves
c. apex

28. Blood passes from the left ventricle out the
    aortic valve to the ____.
    a. lungs
d. pulmonary artery
b. body
e. left auricle
c. aorta

29. The chamber of the heart which pumps oxygenated blood to all parts of the body is the
    ____.
    a. right auricle
d. left ventricle
b. left auricle
e. right ventricle
c. aorta

30. The ____ is another name for the part of the heart called the heart muscle.
    a. apex
d. myocardium
b. epicardium
e. septum
c. endocardium

31. ____ is (are) the part(s) of the heart which controls its contraction and relaxation.
    a. myocardium
d. auricles
b. endocardium
e. septum
c. ventricles

32. The ____ is the name given to the inside lining of the heart wall.
    a. epicardium
d. myocardium
b. endocardium
e. septum
c. pericardium

33. Blood from the body enters through the
    ____.
    a. aortic artery
b. pulmonary veins
c. pulmonary artery
d. superior and inferior vena cava
    e. superior vena cava only

34. The membrane which borders on the inside lining of the pericardium and is connected to the heart muscle is called the
    ____.
    a. extoxim
d. myocardium
b. epicardium
e. ectocardium
c. endocardium

35. The ____ allow(s) blood to travel in one direction only.
    a. septum
d. veins
b. valves
e. tendons
c. arteries

36. The ____ is the common opening between the right auricle and the right ventricle.
    a. mitral valve
b. tricuspid valve
c. septic valve
d. pulmonary valve
e. aortic valve

37. The ____ is a triangular flapped valve between the left auricle and the left ventricle.
    a. aortic valve
b. pulmonary valve
c. septic valve
d. tricuspid valve
e. mitral valve
38. The semi-lunar valves are located at the entrance to the
   _____.
   a. pulmonary vein
   b. superior and inferior vena cava
   c. pulmonary and aortic arteries
   d. mitral and tricuspid valves
   e. ventricles

39. The outside covering of the heart is called the _____.
   a. endocardium
   b. epicardium
   c. pericardium
   d. myocardium
   e. none of these

40. Immediately before entering the aorta, blood must pass through the
   _____.
   a. left ventricle
   b. mitral valve
   c. lungs
   d. superior vena cava
   e. aortic valve

41. Which valve is most like the tricuspid in function?
   a. pulmonary
   b. aortic
   c. mitral
   d. superior vena cava

42. When blood is being forced out the right ventricle, in which position is the tricuspid valve?
   a. beginning to open
   b. open
   c. beginning to close
   d. closed

43. When the blood is being forced out the aorta, it is also being forced out of the
   a. pulmonary veins
   b. pulmonary artery
   c. superior vena cava
   d. cardiac artery

44. The contraction impulse in the heart starts in
   a. the right atricle
   b. both ventricles simultaneously
   c. both auricles simultaneously
   d. the arteries

45. In the diastolic phase the ventricles are
   a. contracting, full of blood
   b. contracting partially full of blood
   c. relaxing, full of blood
   d. relaxing, partially full of blood

46. During the first contraction of the systolic phase, in what position will the mitral valve be?
   a. beginning to open
   b. open
   c. beginning to close
   d. closed

47. During the second contraction of the systolic phase, blood is being forced away from the heart through the
   a. pulmonary and aortic arteries
   b. superior and inferior vena cava
   c. mitral and aortic valves
   d. pulmonary veins

48. When blood is entering through the vena cava, it is also entering through the
   a. mitral valve
   b. pulmonary veins
   c. superior vena cava
   d. aorta

49. When the heart contracts, the
   a. auricles & ventricles contract simultaneously
   b. ventricles contract first, then the aortic valves
   c. right side contracts first, then the left side
   d. auricles contract first, then the ventricles

50. While blood from the body is entering the superior vena cava, blood from the body is also entering through the
   a. pulmonary veins
   b. aorta
   c. inferior vena cava
   d. pulmonary artery

51. When the blood leaves the heart through the pulmonary artery, it is also simultaneously leaving the heart through the
   a. tricuspid valve
   b. pulmonary veins
   c. aorta
   d. pulmonary valve

52. When the pressure in the right ventricle is superior to that in the pulmonary artery, in what position is the tricuspid valve?
   a. closed
   b. open
   c. beginning to close
   d. confined by pressure from the right auricle

53. When the ventricles contract, blood is forced out the
   a. superior and inferior vena cava
   b. pulmonary veins
   c. mitral and tricuspid valves
   d. pulmonary and aortic valves

54. Blood leaving the heart through the aorta had left the heart previously through the
   a. vena cava
   b. pulmonary artery
   c. cardiac artery

55. When the blood in the aorta is exerting a superior pressure on the aortic valve, what is the position of the mitral valve?
   a. closed
   b. open
   c. beginning to open
   d. confined by pressure from the right ventricle
56. When the tricuspid and mitral valves are forced shut, in what position is the pulmonary valve?
   a. closed   c. open
   b. beginning to open  d. beginning to close

57. During the second contraction of the systolic phase, in what position is the aortic valve?
   a. fully open   c. partially closed
   b. partially open   d. fully closed

58. Blood is being forced out the auricles simultaneously as blood is
   a. entering only the vena cavas
   b. being forced out the pulmonary and aortic valves
   c. passing through the tricuspid and mitral valves
   d. being forced out through the pulmonary artery

59. If the aortic valve is completely open, the
   a. second contraction of the systolic phase is occurring
   b. diastolic phase is occurring
   c. tricuspid & mitral valves are completely open
   d. blood is rushing into the right & left ventricles

60. When the heart relaxes, the
   a. auricles relax first, then the ventricles
   b. right side relaxes first, then the left side
   c. left side relaxes first, then the right side
   d. ventricles relax first, then the auricles
Appendix M

CRITERION TESTS (CHINESE VERSION)

Note: To view Appendix M with Adobe Acrobat 4.0 or lower, Asian Language Support (ALS) must be installed. To view with Adobe Acrobat Reader 5.0, go to Adobe's web site at http://www.adobe.com to download the free Traditional Chinese font pack. Adobe also offers a free download of Acrobat Reader in Traditional Chinese available from its web site.
辨識測驗

請於每題選出一個最能代表箭頭所指之處的答案，並在答案紙上以2號鉛筆作答。

1. 箭頭1所指的是 ____
(a) 心隔
(b) 主動脈
(c) 肺動脈
(d) 三尖瓣
(e) 以上皆非

2. 箭頭2所指的是 ____
(a) 上腔靜脈
(b) 下腔靜脈
(c) 肺動脈
(d) 三尖瓣
(e) 主動脈

3. 箭頭3所指的是 ____
(a) 右心室
(b) 右心房
(c) 左心室
(d) 左心房
(e) 心肌

4. 箭頭4所指的是 ____
(a) 肺動脈瓣
(b) 肺靜脈
(c) 主動脈瓣
(d) 三尖瓣
(e) 僧帽瓣

5. 箭頭5所指的是 ____
(a) 主動脈
(b) 肺動脈瓣
(c) 上腔靜脈
(d) 下腔靜脈
(e) 肺靜脈

6. 箭頭6所指的是 ____
(a) 主動脈瓣
(b) 肺動脈瓣
(c) 僧帽瓣
(d) 三尖瓣
(e) 半月瓣

7. 箭頭7所指的是 ____
(a) 左心室
(b) 右心室
(c) 右心房
(d) 左心房
(e) 脈管空間

8. 箭頭8所指的是 ____
(a) 心肌
(b) 外胚層
(c) 圓心膜
(d) 心內膜
(e) 心外膜

9. 箭頭9所指的是 ____
(a) 心內膜
(b) 心肌
(c) 圓心膜
(d) 心內膜
(e) 心外膜

10. 箭頭10所指的是 ____
(a) 心外膜
(b) 圓心膜
(c) 心隔
(d) 心肌
(e) 主動脈瓣

11. 箭頭11所指的是 ____
(a) 心內膜
(b) 圓心膜
(c) 心隔
(d) 心肌
(e) 主動脈瓣

12. 箭頭12所指的是 ____
(a) 圓心膜
(b) 心肌
(c) 圓心膜
(d) 心內膜
(e) 心外膜

13. 箭頭13所指的是 ____
(a) 塵心膜
(b) 心內膜
(c) 心壁膜
(d) 徹蒂膜
(e) 心肌

14. 箭頭14所指的是 ____
(a) 右心室
(b) 左心室
(c) 左心房
(d) 右心房
(e) 心尖

15. 箭頭15所指的是 ____
(a) 肺靜脈
(b) 筆
(c) 主動脈
(d) 圓心膜
(e) 以上皆非

16. 箭頭16所指的是 ____
(a) 靜脈瓣
(b) 肺動脈瓣
(c) 三尖瓣
(d) 僧帽瓣
(e) 主動脈瓣

17. 箭頭17所指的是 ____
(a) 上腔靜脈
(b) 三尖瓣
(c) 主動脈瓣
(d) 肺動脈瓣
(e) 僑帽瓣
18. 箭頭 18 所指的是 ____
   (a) 右心房
   (b) 右心室
   (c) 左心房
   (d) 左心室
   (e) 半月腔室

19. 箭頭 19 所指的是 ____
   (a) 下腔靜脈
   (b) 上腔靜脈
   (c) 主動脈
   (d) 肺靜脈
   (e) 肺動脈

20. 箭頭 20 所指的是 ____
   (a) 下腔靜脈
   (b) 主動脈
   (c) 肺動脈
   (d) 心隔
   (e) 上腔靜脈

21. ____ 是心臟構造中，腔壁最厚的部分

24. 血液從右心室經過____流入肺部
   (a) 三尖瓣
   (b) 主動脈
   (c) 肺動脈
   (d) 肺靜脈
   (e) 上腔靜脈

25. 心臟最強壯的部份是 ____
   (a) 左心室
   (b) 主動脈
   (c) 心隔
   (d) 右心室
   (e) 鞘

26. 當血液從肺部流回心臟時，它是進入____
   (a) 右心房
   (b) 肺靜脈
   (c) 左心室
   (d) 右心室
   (e) 肺動脈

27. 讓血液從心臟流出的管道稱為____
   (a) 靜脈
   (b) 動脈
   (c) 心尖
   (d) 鞘
   (e) 瓣膜

28. 血液從左心室經過主動脈流入____
   (a) 肺部
   (b) 身體
   (c) 主動脈
   (d) 肺動脈
   (e) 左心房

29. 心臟的腔室，其將加入氧氣的血液輸出到身體各部的是____
   (a) 右心房
   (b) 左心房
   (c) 主動脈
   (d) 左心室
   (e) 右心室

30. 心臟的肌肉稱為____
   (a) 心尖
   (b) 心外膜
   (c) 心內膜
   (d) 心肌
   (e) 心隔

31. 控制心臟收縮與鬆弛的是____
   (a) 心肌
   (b) 心內膜
   (c) 心室
   (d) 心房
   (e) 心隔
32. 心臟內襯的膜稱為____
   (a) 心外膜
   (b) 心內膜
   (c) 圍心膜
   (d) 心肌
   (e) 心隔

33. 身體的血液從____進入心臟
   (a) 主動脈
   (b) 肺靜脈
   (c) 肺動脈
   (d) 上、下腔靜脈
   (e) 上腔靜脈

34. 心臟複壁薄囊的內壁稱為____，它在圍心膜內並和心臟的肌肉相連
   (a) 心膜
   (b) 心外膜
   (c) 心內膜
   (d) 心肌
   (e) 心壁膜

35. ____使血液只能單向流動
   (a) 心隔
   (b) 瓣膜
   (c) 動脈
   (d) 靜脈
   (e) 腱

36. 右心房與右心室之間的瓣膜是____
   (a) 僧帽瓣
   (b) 三尖瓣
   (c) 隔間瓣
   (d) 肺動脈瓣
   (e) 主動脈瓣

37. ____是介於左心房與左心室之間的一片三角形瓣膜
   (a) 主動脈瓣
   (b) 肺動脈瓣
   (c) 隔間瓣
   (d) 三尖瓣
   (e) 僧帽瓣

38. 半月瓣位於____的入口
   (a) 心膜
   (b) 肺靜脈
   (c) 上、下腔靜脈
   (d) 僧帽瓣及三尖瓣
   (e) 心室

39. 心臟的外壁稱為____
   (a) 心內膜
   (b) 心外膜
   (c) 圍心膜
   (d) 心肌
   (e) 以上皆非

40. 即將進入主動脈前，血液必先經過____
   (a) 左心室
   (b) 僧帽瓣
   (c) 肺
   (d) 上腔靜脈
   (e) 主動脈瓣

理解測驗

請於每題選出一個最好答案，並在答案紙上以2號鉛筆作答。

41. 與三尖瓣功能最相像的是____
   (a) 肺動脈瓣
   (b) 主動脈瓣
   (c) 僧帽瓣
   (d) 上腔靜脈

42. 當血液從右心室壓出時，三尖瓣是____
   (a) 開始打開
   (b) 開始關閉
   (c) 打開的
   (d) 關閉的

43. 當血液受壓流入主動脈時，血液亦受壓流入____
   (a) 肺靜脈
   (b) 肺動脈
   (c) 上腔靜脈
   (d) 心室

44. 心臟收縮的脈動從____開始
   (a) 右心房
   (b) 左、右心室同時
   (c) 左、右心房同時
   (d) 動脈
45. 心室在舒張期的時候是____
   (a) 收縮，充滿血液
   (b) 收縮，部份充滿血液
   (c) 鬆弛，充滿血液
   (d) 鬆弛，部份充滿血液

46. 收縮期的第一次收縮，僧帽瓣是____
   (a) 開始打開
   (b) 打開的
   (c) 開始關閉
   (d) 關閉的

47. 收縮期的第二次收縮，血液經由____從心臟流出。
   (a) 肺動脈及主動脈
   (b) 上、下腔靜脈
   (c) 三尖瓣及僧帽瓣
   (d) 肺靜脈

48. 當血液經上、下腔靜脈流入心臟時，血液也另外同時由____流入。
   (a) 僧帽瓣
   (b) 肺靜脈
   (c) 肺動脈
   (d) 主動脈

49. 當心臟收縮時，____
   (a) 心房與心室同時收縮
   (b) 心室較心房先收縮
   (c) 心臟右邊較左邊先收縮
   (d) 心房較心室先收縮

50. 當自來身體的血液流入上腔靜脈時，來自身體的血液亦流入了____
   (a) 肺靜脈
   (b) 主動脈
   (c) 下腔靜脈
   (d) 肺動脈

51. 當血液經過肺動脈流出心臟時，它同時也經由____流出心臟。
   (a) 三尖瓣
   (b) 肺靜脈
   (c) 主動脈
   (d) 肺動脈瓣

52. 當右心室的壓力大於肺動脈的壓力時，三尖瓣是____
   (a) 關閉的
   (b) 開始打開
   (c) 開始關閉
   (d) 受到右心室壓力的控制

53. 當心室收縮時，血液從____壓出。
   (a) 上、下腔靜脈
   (b) 肺靜脈
   (c) 三尖瓣及僧帽瓣
   (d) 肺動脈瓣及主動脈瓣

54. 血液經由主動脈離開心臟前，曾經經由____離開心臟。
   (a) 上、下腔靜脈
   (b) 肺靜脈
   (c) 肺動脈
   (d) 三尖瓣及僧帽瓣

55. 當主動脈的血液對主動脈瓣加諸壓力時，僧帽瓣是____
   (a) 關閉的
   (b) 打開的
   (c) 開始打開
   (d) 受到右心室壓力的控制

56. 當三尖瓣及僧帽瓣受到壓力而關閉時，肺動脈瓣是____
   (a) 關閉的
   (b) 開始打開
   (c) 開始關閉
   (d) 部份關閉的
   (e) 完全關閉的

57. 當僧帽瓣受到壓力而關閉時，主動脈瓣是____
   (a) 完全打開的
   (b) 部份打開的
   (c) 開始打開
   (d) 打開的
   (e) 開始關閉
   (f) 關閉的

58. 當血液從心房壓出時，血液____
   (a) 只流入上、下腔靜脈
   (b) 流經肺動脈瓣及主動脈瓣
   (c) 流經三尖瓣及僧帽瓣
   (d) 過經肺動脈流出

59. 如果主動脈瓣是完全開啓的，____
   (a) 心臟收縮期的第二次收縮正在進行中
   (b) 心臟舒張期正在進行中
   (c) 三尖瓣及僧帽瓣完全開啓
   (d) 血液流入左、右心室

60. 當心臟收縮時，____
   (a) 心房較心室先收縮
   (b) 心臟右邊較左邊先收縮
   (c) 心臟左邊較右邊先收縮
   (d) 心室較心房先收縮

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VITA

Kelly Ann Chiemi Yamashiro

Education

Master of Library and Information Studies, University of Hawaii at Manoa, Honolulu, Hawaii, 1997.

Bachelor of Arts in Psychology, University of Hawaii at Manoa, Honolulu, Hawaii, 1992.

Selected Experience

Summer 2000. Graduate Intern. College Development Team, General Motors University, General Motors Corporation, Detroit, Michigan, USA.
• Formulated recommendations for the implementation and deployment of training evaluation Levels 1, 2 and 3.
• Developed job aids to support the implementation of evaluation Levels 1, 2 and 3.

• Designed industry knowledge training for the various AA service lines.

• Designed information literacy web tutorials for Penn State's freshmen seminar programs.

Publications

