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Abstract

Introductory biology courses typically present topics on related biological systems across separate chapters and lectures. A complete foundational understanding requires that students understand how these biological systems are related. Unfortunately, spontaneous generation of these connections is rare for novice learners. These experiments focus on the potential of developing a means to enhance the connections students make between separate, but related, biological systems. In a series of three experiments, the conditions that support students’ development of connections between multiple biology texts are considered.

Experiment 1 tests the possibility that students’ integration of biological systems presented in separate texts can be improved if students know that these texts should be integrated. This experiment tested two conditions; participants either received instructions to integrate between two texts or instructions to comprehend. The results from this experiment suggest that providing instructions alone is not sufficient to impact participants’ integration. In Experiment 2, participants were delivered the same instructions as Experiment 1, with an added condition that provided students with additional support encouraging a deeper understanding of the integration task. The results from Experiment 2 also offer no evidence that providing students with instructions to integrate between two systems is sufficient, even if participants understood the integration task.

Experiment 3 tests the effects of providing additional support to participants for how to integrate. Three conditions compared the effects of an integration intervention (II) and a comprehension intervention (CC) to a note-taking control task (CT). Participants in the CT condition spent the greatest amount of time reading the text(s) and scored the highest on a measure of small-grain comprehension. Despite lower comprehension scores and less time-on-task, participants in the II intervention scored significantly highest on a measure of large-grain integration. Students’ self-reported strategy use indicates that the integration intervention was effective because it stimulated student engagement toward use of integration strategies.
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Finally, I would like to dedicate this dissertation in loving memory of my father, Carl, who showed me boundless love and gave me inspiration to push forward, no matter how hard things may be.
Chapter 1

Introduction and Statement of Purpose

Background

The National Academy of Sciences reports that throughout the 20th century rapid innovation in science resulted in a separation between various fields within biology (National Research Council, 2009). In recent years, there has been a movement to reconnect these sub-disciplines into a “New Biology” (National Research Council, 2009). This new movement emphasizes the importance for biologists to “integrate information across many organisms, from multiple levels of organization (such as cells, organisms, and populations) and about entire systems (such as all the genes in a genome or all the cells in a body) to gain a new integrated understanding that incorporates more and more of the complexity that characterizes biological systems” (National Research Council, 2009, p. 41).

A series of reports over the past twenty years has called for a transformation in undergraduate education, in order to produce educated biologists prepared to meet these expectations (Labov, Reid, & Yamamoto, 2010). According to Vision and Change, one of these reports by the American Association for the Advancement of Science (AAAS) in 2011, typical introductory biology courses rely on both textbooks and instructor-led lectures to teach students. Furthermore, faculty who teach these courses find it “easy to fall into the trap of… emphasize[ing] rote memorization of isolated facts, rather than designing a course that uses those same facts to promote a deeper understanding of basic concepts” (AAAS, 2011, p. 21). This memorization of isolated facts is not conducive to producing the sophisticated knowledge required of biologists, as “future scientists and nonscientists alike must become adept at making connections among seemingly disparate pieces of information [emphasis added], concepts, and questions, as well as be able to understand and evaluate evidence” (AAAS, 2011, p. 3). Stressing the importance of stimulating change toward this goal, the report concludes with a call to action,

Undergraduate biology education must become more concept oriented and concentrate more on integrating factual knowledge within those concepts. Given the rapid rate of new information produced each year, much of what undergraduates learn in a first-year biology course may change by the time they graduate
from college. It is, therefore, important not to consider factual content as the sole basis for undergraduate biology, especially at the introductory level. Instead, we must **teach students how to integrate facts into a large conceptual context** [emphasis added] so that the students become more engaged with the science, more curious, and better able to pursue questions on their own. Facts divorced from concepts and context are not effective in helping students learn and understand science. (AAAS, 2011, p. 57)

**Need for an Intervention**

Vision and Change (AAAS, 2011) offers over a dozen instructional methods for college and university biology faculty to implement more effective teaching practices into their courses. While these proposed methods might be effective tools for instruction, students are also required to learn from their textbook. Students in introductory biology courses often use the textbook as a resource to supplement their learning from course lectures. One popular textbook, Saladin’s (2010) *Anatomy & Physiology*, contains twenty-nine chapters. Like many other anatomy and physiology textbooks, the chapters are separated by body system (e.g., “the endocrine system”, “the circulatory system”, “the urinary system”, and “the digestive system”).

This topical separation of different body systems into different chapters is consistent with the coverage of these topics in the course itself. College instructors design lectures to cover body systems one-by-one. Although the lectures and textbooks include indications of how each system influences or is influenced by other systems, the reality is that these body systems are generally treated as separate topics. The reality is also that learners often fail to draw connections across related topics that are presented in isolation of one another. Unfortunately, these realities combine to create a situation in which biology students are unlikely to generate the connections across systems that are necessary for understanding how the body system operates as a whole. One approach to address this shortcoming is to draw upon the research of multiple-text integration, which specifically addresses how readers integrate information derived from different texts. If students can be helped to construct holistic, interconnected knowledge representations of systems within the body while reading their textbook, this understanding can be translated into the topics of the classroom. To consider this possibility, however, we must first examine the requirements of a successful intervention as well as the meaning of integration in the context of a college science course.
Requirements of the intervention.

One concern regarding the instructional recommendations set forth by Vision and Change is the substantial demand placed on the instructor. For instance, it is recommended that students be engaged in, “Authentic research: open-ended, student-designed, inquiry-driven, mentored research activities.” Under this recommendation an instructor would engage students in “ongoing potentially publishable research in undergraduate laboratory courses to enhance their conceptual understanding and their factual and procedural knowledge related to biological processes and research activities” (2011, p. 25). Despite the empirically based and sound nature of these recommendations, “many biology faculty continue to be skeptical about investing the time needed to improve the teaching and learning in their undergraduate classes” (AAAS, 2011, p. 49). Certainly, many instructors at large institutions would raise questions of scale. “How can hundreds of students be engaged in these research efforts each semester?”, is a reasonable question. In addition, instructors are likely to question how to increase this engagement without sacrificing a strong understanding of the basic conceptual foundation.

Whilst the value of instructor-intensive interventions is a worthy debate, there is an alternative way to address students’ conceptual understanding and increase the tendency to make connections across course topics. In short, interventions can be developed that are instructor independent, draw upon existing course resources (e.g., the textbook), and can be completed outside of class meeting times. Developing and refining interventions that meet these requirements should be a major focus of future research on how to improve learning outcomes for biology students. Certainly, a major consideration for such an intervention will be the provision of adequate support so that the typical college student may successfully meet the goal of the task. In this case, where the focus is on the integration of knowledge across biological systems, meeting that goal means that the student not only acquires knowledge of the structures and functions within each system, but also understands how these systems influence, and are influenced by, one another. This integration goal can be achieved by determining the level of support and guidance necessary for college students to integrate knowledge gained through independent reading assignments.
Defining integration in the context of multiple science texts.

The English word integration refers to “an act or instance of combining into an integral whole” (Integration, n.d.). Integration is when information from multiple texts is connected into a single, integrated knowledge representation (Van Meter & Firetto, 2008). The benefits of generating an integrated representation are twofold. First, readers who generate an integrated knowledge representation from multiple texts have a greater quantity of concepts than readers who generate a representation from a single isolated text. This is because the integrated knowledge representation includes unique concepts from each text as well as the overlapping concepts from multiple texts. Additionally, the quality of integrated representations is better and allows for greater flexibility (Van Meter & Firetto, 2008; Van Meter & Garner, 2005). Applying the definition of integration to the context of this dissertation, in which college students are learning about different body systems in an introductory biology course, integration can be defined as an act or instance of combining seemingly disparate course content into an integrated representation of that content.

Although content pertaining to these biological systems are also covered in course lectures, the primary focus of the dissertation is on the integration of text-based course content. As such, the specific type of integration resulting from reading multiple texts can be more specifically defined as an act or instance of combining content from more than one text into an integrated representation of that content. Alternatively, the related idea synthesis can provide additional clarification of the term. By synthesizing and integrating multiple texts, a reader is able to generate connections between related content despite that the content may be presented in the form of separate texts.

Although only limited research on the integration of multiple texts has been conducted in the sciences (Cerdán & Vidal-Abarca, 2008), there does exist some evidence regarding potentially promising avenues for designing instructional interventions to support integration of multiple science texts. In various content areas, certain tasks have been tested for their ability to promote integration between texts. For example, tasks such as summary and argument essays (Gil, Bråten, Vidal-Abarca, & Strømsø, 2010a; 2010b; Wiley & Voss, 1999), writing integration essays (Cerdán & Vidal-Abarca, 2008), as well as providing instruction to readers to integrate (Britt & Sommer, 2004) have potential, but there are mixed findings.
**Purpose of the Present Research**

The purpose of the current research is to develop an intervention that promotes an integrated understanding of different, but related, biological systems. To meet the desired requirements of an effective intervention, this intervention will need to be instructor-independent, utilize textbook course resources, and provide the necessary and sufficient support to prompt the integration of concepts between multiple texts. The research presented here tests an intervention that facilitates integration between different biological systems that are traditionally presented in different chapters. Specifically, a set of three consecutive experiments tests instructions and an intervention intended to support the integration of concepts between biological systems. In each of these studies, participants were presented with tasks designed to direct attention to the generation of inferences between concepts in different texts. In each experiment, enhancements were made to assess and further refine the tasks with the goal of identifying the necessary and sufficient conditions for text integration to occur.

The first two studies present task instructions, prior to reading, that either directed participants to read for integration or comprehension. Experiment 1 tests whether instructions that make students aware of the need to integrate texts is sufficient to promote integration between two texts. This experiment asks, “Can students integrate two biology systems if they know that this content should be integrated?” The second experiment provides an additional test of this ‘know’ hypothesis and also goes one step further. Specifically, Experiment 2 asks, “Can students successfully integrate biology content if they understand what integration means?” Experiment 3 asks the question, “Can students successfully integrate biology content if given support to help them accomplish integration?” In this experiment, which actually contains a set of two studies, participants receive know and understand instructions along with additional efforts to support readers’ efforts to integrate the biology content. This experiment proposes that, although knowing and understanding are necessary, they are not sufficient without specific support that directs students how to accomplish integrating. In general the following questions are addressed:

1. Do participants given instructions to integrate generate more connections between two biology systems than participants given instructions to comprehend?
(2) Do participants given instructions to integrate, and support to help them understand the idea of integration, generate more connections between two biology systems than those given only instructions to integrate or those to comprehend?

(3) Do participants given an intervention consisting of instructions to integrate and support to help them understand the idea of integration and an intervention to inspire integration stimulate the generation of more connections between two biology systems than those given an intervention focused on comprehension or a control task?

(4) What role do the individual difference variables of Need for Cognition and strategy use play in participants’ ability to generate connections between two biology systems?
Chapter 2

Literature Review

Introduction

The purpose of the experiments conducted in this dissertation is to study the effects of tasks on students’ integration of biology content. In three successive experiments, the tasks (i.e., instructions or instructions with an intervention) and texts (i.e., two separate texts or a single combined text) were both manipulated to assess the impact on measures of comprehension and integration. These studies also consider whether students are as able to integrate between the systems when they are presented as separate texts compared to when the same information is presented as a single combined text. More importantly, the goal was to develop a self-contained method of supporting integration without imposing on the instructor. This chapter presents an overview of the related theoretical and empirical research supporting these studies.

Theoretical Framework

Kintsch’s (1988) Construction-Integration (CI) Model is the foundational framework for much of the research on text comprehension. The central principles of the model focus solely on the comprehension of a single text. Thus, the use of this model in its application to frame how introductory biology students would comprehend and integrate between chapters or texts on the topic of different systems is limited. New frameworks have extended Kintsch’s model to account for the differences in reading multiple texts: the Documents Model (Perfetti, Rouet, & Britt, 1999), and consequently the Multiple Documents – Task-based Relevance Assessment and Content Extraction (MD-TRACE) model (Rouet & Britt, 2011). These three frameworks provide the theoretical background for the three experiments contained within this dissertation.
**Kintsch’s CI Model.**

Kintsh’s CI Model maintains that comprehension of text occurs through a process of both construction and integration. During *construction*, words on a page are formed into propositions. These constructed propositions are then connected to others through element overlap, creating a network of propositions; new propositions are incorporated into this network through *integration*. Thus, a mental representation of the text is formed through a series of iterative cycles between these two processes (Kintsch, 1988).

Both top-down and bottom-up processes mediate the formation of this knowledge representation. Top-down processes act to “guide comprehension” while bottom-up processes act to “constrain it” (Kintsch, 2005, p. 125). Both of these processes are equally critical. With respect to top-down processes, readers’ prior knowledge as well as the context of the task has an impact on the construction of the knowledge representation, essentially acting as a filter through which the reader reads. Alternatively, when a reader forms propositions from the text and an existing proposition in the knowledge network matches it, direct activation of existing knowledge can occur through bottom-up processes (Kintsch, 2005). The learner’s strategic comprehension processes, in addition to prior knowledge, impact the constructed knowledge representation.

Van Dijk and Kintsch (1983) proposed three different levels of knowledge representations that could be formed from this process. The first and most rudimentary of these is the surface representation. A surface representation of the text indicates a superficial knowledge representation that replicates the verbatim text. A textbase representation reflects an understanding of the “semantic and rhetorical structure of the text” (Kintsch, 1994, p. 294). A situation model, the third type, is evidenced when the reader is able to generate elaborative inferences that connect propositions both within the text and between the text and prior knowledge. A reader who constructs a situation model stores a robust representation of the text (van Dijk & Kintsch, 1983).

**The Documents Model.**

Understanding how readers comprehend multiple texts through the construction-integration model is limited, because often it is not possible to construct a singular situation model from a set of texts (Perfetti et al.,
To account for this, Perfetti and colleagues developed the documents model, one of the earliest models framing the comprehension of multiple texts. This documents model is comprised of two important subcomponents: a situations model and an intertext model. The situations model is similar to the situation model from Kintsch’s CI model, but instead, recognizes the plurality of situations, since the comprehension of “multiple documents provide[s] multiple situations” (Perfetti et al., 1999, p. 108). Acknowledgment of the importance of both the unique information presented in each text as well as the information that is overlapping between the texts is critical (Britt, Perfetti, Van Dyke, & Gabrys, 2000). The intertext model, which is unique to multiple-text comprehension, is where the learners evaluate the texts’ source, content, and rhetorical goals (i.e., document nodes) as well as the relationship between the documents (i.e., intertext predicates).

Reading multiple texts may result in a series of isolated situation models, but “under certain circumstances, the reader may try to integrate the information in the two texts” (Perfetti et al., 1999, p. 111), leading to the creation of an Integrated Documents Model. Perfetti and colleagues proposed several characteristics that might stimulate the formation of an Integrated Documents Model: tasks/goals, and expertise. Consistent with the top-down processes of single-text comprehension, the tasks and goals of a learner (e.g., study directions, assigned task) likely influence the construction of the representation. Because the documents model was developed specifically for readers faced with multiple historical documents, the application of the model toward the types of biology texts used in this study is limited.

**MD-TRACE Model.**

In 2011, the documents model was expanded into the Multiple Documents – Task-based Relevance Association and Content Extraction (MD-TRACE; Rouet & Britt) model. The revised model accounts for broader types of texts rather than historical documents. Like Kintsch’s CI model, the MD-TRACE model (Rouet & Britt, 2011) uses an iterative framework for understanding how multiple texts are comprehended. The framework is the result of the influence of both internal and external resources. Below, these resources are defined, as well as the process of the MD-TRACE model.
Within the model, reader’s internal resources are classified as either those that are permanent or those that are transitory. Permanent resources include a reader’s prior knowledge along with reading-related cognitive capabilities; transitory resources include the reader’s representation of the presented task and documents, as well as how the reader recognizes the relationship between the documents (Rouet & Britt, 2011). External resources in the MD-TRACE model include the external task specifications, the informational resources and the reader-generated resources. Task specifications are inherent in the majority of multiple-text situations and encompass the actual assignment or purpose for reading multiple documents as well as instructions delivered, constraints surrounding the task (e.g., time limits, environmental circumstances, etc.), and expectations of performance surrounding the task. The informational resources are the set of documents (i.e., texts) that are available to the learner. Depending on the situation, this may be limited to a set of two texts but may be as vast as an entire library and/or the Internet. Finally, the reader-generated products are the resulting products (e.g., notes) as the learner navigates through the documents (Rouet & Britt, 2011).

The process of learning from multiple texts first requires that a task model be constructed to frame the task. Information from the external task specifications (e.g., the directions for the assignment), as well as any associated permanent internal resources (e.g., content prior knowledge), is gathered and goals are set to frame the “range of procedures to be conducted” (p. 32). In step two, readers consider whether the task or goal can be completed with knowledge from memory, or if text processing is necessary. Readers in step three assess the relevance of the texts, and devote various levels of processing to text comprehension and work to integrate the information, thus forming a documents model. Once step four is reached, the reader is able to work toward accomplishing the task, where it is finally assessed in step five. Throughout the entire process, readers utilize self-regulation skills (Winne & Hadwin, 1998) guiding the iterative process of forming and refining the final product (Rouet & Britt, 2011).

Summary.

The MD-TRACE model is the most current and updated theoretical model of how readers comprehend multiple texts; this is the model that serves as the foundation for the experiments conducted in this dissertation. In particular, the two major components of the model salient for this research are the external task specifications (e.g.,
instructions for the task) and the specific information resources available (e.g., the texts to be read). These two components provided the theoretical support for use of the two independent variables throughout the three experiments.

**Review of Research on the Integration of Multiple Texts**

College students are frequently required to learn from a variety of different texts to excel in their courses (Goldman et al., 2011). Unfortunately, while a substantial amount of research has been directed at understanding the cognitive processes that support comprehension and learning from text (Graesser, Singer, & Trabasso, 1994), much of that research is on the comprehension of single, isolated texts, but the authentic situations that readers are presented with are vastly different (Goldman, 2003). Britt and Sommer contend that:

Students routinely learn by reading multiple sources on the same topic such as textbooks, secondary sources, lectures, journal articles, and websites. The goal of such reading is to acquire a single, integrated representation of situations, processes or objects described by the sources. (2004, p. 313)

Because college students generally read multiple texts that cover various topics over the length of the course (Bråten & Strømsø, 2003), explicit research on how students comprehend multiple texts, and how this multiple-text integration can be enhanced, is necessary.

The literature pertaining specifically to the integration of multiple texts is relatively small when compared to the literature pertaining to single-text comprehension. Fortunately, the body of work is ever expanding. Much of the early research is focused on text “documents” within the domain of history (Wineburg, 1991; VanSledright & Kelly, 1998; Wiley & Voss, 1999; Stahl, Hynd, Britton, McNish, & Bosquet, 1996; Hynd, 1999; Green, 1994). This is perhaps due to the natural tendency for historians to utilize multiple primary source documents when studying historical events (Wineburg, 1991). Recent studies have expanded the field by extending the text content area to other domains such as politics (Bråten & Strømsø, 2003). Yet, more research is needed to understand how college students integrate multiple texts in and science (Cerdán & Vidal-Abarca, 2008; Gil et al, 2010a; 2010b). The following sections present some of the trends from the research on multiple-text integration.
Novice learners do not fluently integrate multiple texts.

A landmark study by Wineburg (1991) drew attention to how readers comprehend multiple texts. The study compared eight expert historians and eight novices thinking aloud while reading a set of historical documents. Analysis of the verbal protocols revealed three categories of verbalizations, Wineburg termed these heuristics: sourcing (detecting and identifying the source of the document and the influence the source has on the other documents), corroboration (comparing, contrasting, or relating the documents), and contextualization (positioning the document within the greater framework of space and time, as well as with other documents). Comparisons between experts and novices showed the “predictable but not trivial finding” that experts read the texts “in more sophisticated ways than a group of high school students” (p. 83). When compared to novices, experts were statistically more likely to look at the both the attribution of the document before reading (i.e., sourcing), as well as the previous texts while reading (i.e., corroboration). Ultimately, Wineburg (1998) concluded that, “creating coherence from this textual mélange is a major cognitive achievement” (p. 237).

Various researchers have conducted follow-up studies on these heuristics. For example, Stahl and colleagues (Stahl et al., 1996) also found that novice historians struggle to implement the three heuristics described by Wineburg (1998). Analysis of 20 advanced placement high school students charged with taking notes while reading a set of historical texts about the Gulf of Tonkin resulted in generally low incidences of students employing these heuristics.

These same patterns have been found with even younger readers. Wolfe and Goldman (2005), for example, studied 44 sixth grade students who thought aloud while reading contradictory texts on the Fall of Rome. Analysis of the think aloud protocols revealed two primary types of verbalizations: paraphrases (22%) and elaborations (58%). Elaborations were coded into subcategories pertaining to the location of the connection made; 49% of elaborative verbalizations referenced general prior knowledge, 16% a previous point in the text, 18% a previous text, and 17% a previous verbalization. While overall the proportion of elaborations that referenced a previous text was small, there was a significant positive correlation with the posttest reasoning score. The results suggest that the generation of connections between texts is related to deeper conceptual understanding for even these young readers.

Strømsø, Bråten and Samuelstuen (2003) extended this research to college students studying law texts to prepare for an exam and found similar patterns. In this study, seven law students thought aloud while reading texts
relevant to their course at three different points throughout the semester. Verbal protocols were coded into four main categories: memorization (27%), elaboration (31%), organization (11%), and monitoring (30%). Of the elaborative verbalizations, 36% connected information to other texts. While this percentage is higher than the percentage found by Wolfe and Goldman (2005), considering the difference in age and expertise of the readers, that increase would be expected.

Overall, these patterns indicate that novice readers’ ability to fluently integrate multiple texts is more of the exception rather than the rule. However, it is clear that some novices are able to integrate. Furthermore, experts are more likely to integrate than novices. Details pertaining to exactly what facilitates integration are unclear (Kurby, Britt, & Magliano, 2005), but attempts to address this in the literature are considered further in the next section.

**Tasks that influence learners’ integration of multiple texts.**

Recent research on the integration of multiple texts has focused on methods for prompting the cognitive processes that result in integration. As theorized in the MD-TRACE model (Rouet & Britt, 2011), there is evidence that certain tasks may facilitate this process. Various instructional interventions (Britt & Aglinskas, 2002; Nokes, Dole & Hacker, 1999) and tasks, such as argument essay writing (Gil et al., 2010a; 2010b; Wiley & Voss, 1999) and intertext essay writing (Cerdán & Vidal-Abarca, 2008), have been shown to positively impact various outcome measures assessing integration.

In an effort to consider whether novices can improve their ability to integrate texts, few researchers have studied the effects of teaching learners how to employ Wineburg’s (1991) three heuristics (i.e., corroboration, contextualization, and sourcing). Nokes et al. (1999) studied 245 high school students taking a history class to assess the impact of heuristic instruction on learning. The study took part during a 15-day instructional unit on the 1920’s and 1930’s in the United States. During the unit, teachers delivered ten 1-hour instructional sessions, all of which were either on heuristic instruction or content instruction. The participants receiving heuristic instruction were provided with direct instruction for how to use each of the heuristics, when each of the heuristics should be applied, and why using heuristics are important. Teachers then modeled the use of the heuristics and students worked in small groups to practice using the heuristics on the assigned text materials. Participants receiving content instruction only
were provided additional background material to complement the text; instruction centered on “helping them learn the historical content in the texts” (p. 495). Participants in both conditions were given texts in one of two formats. The texts had equivalent information but were either presented in the form of a traditional textbook or ten independent texts. After completion of the unit, results showed no difference in the use of heuristics based on the type of instruction they were delivered. However, students who read ten independent texts had more instances of sourcing and corroboration than students who read from a traditional textbook (contextualization was not analyzed because of low incidence).

In Wiley and Voss’ (1999) influential study, participants were assigned to one of three task conditions: a narrative task, a history task, or an argument task. After task assignment, participants read either a set of multiple texts or a single combined text. Participants who read multiple texts and were assigned to the argument task exhibited the highest recall of text information, and overall, participants assigned to the argument task made the most connections (e.g., inferences, correlations, temporal links, etc.). In contrast, however, Naumann, Wechsung and Krems (2009) studied the effect of two of three task conditions used in Wiley and Voss’ (1999) study (i.e., narrative task and argument task) but found no effect of the task on integration. After task assignment to one of the two tasks, all participants read eight texts about Panama. There were no significant differences between participants assigned to the argument task and those assigned to the narrative task on an inference verification measure.

In the same vein, Gil, Bråten, Vidal-Abarca, and Strømsø (2010a) studied the effect of writing summary or argument essays on integration for participants assigned to read a set of seven texts. In this study, participants who wrote summary essays had greater understanding and integration of the texts than participants instructed to write argument essays. These researchers later followed up their findings in an attempt to explain the “somewhat surprising” (Gil et al., 2010b, p. 158) results of their previous study. The follow-up study replicated the former research while hypothesizing that the effect of task may be moderated by prior knowledge. Results showed that high prior knowledge students who read with the purpose of generating arguments outperformed those who read with the purpose of summarization on posttest measures assessing the ability to generate inferences across text. There were no differences between students with low prior knowledge. Although the effects of argumentation task remain inconclusive, the overall finding that different tasks may influence the strategies that readers use, and therefore the degree to which readers integrate multiple texts is salient.
Research on effect of strategies on how students learn in academic domains is exhaustive (Pressley & Afflerbach, 1995; Goldman, 1997). Alexander (2003) asserts that readers who are in early stages of expertise development have “characteristically limited and fragmented knowledge. This piecemeal knowledge comes with… strong reliance on surface-level strategies” (p.12). These novice students “require guidance in determining what content is central and what is peripheral” (p. 12), along with assistance regulating their learning, as they “do not come equipped with the cognitive and metacognitive/self-regulatory strategies they need” (p. 12).

These emphases are consistent with the recommendations for strategies set forth to enhance multiple-text integration by Afflerbach and Cho (2009). Their work extends previous work on constructively responsive reading strategies (initially for single-text comprehension). They contend that “[l]inking strategies are pivotal for understanding multiple texts, and constructively responsive reading strategies contribute to meaning construction, monitoring comprehension, and evaluating texts at the cross-textual level of reading” (p. 80). They propose three components that can be implemented in future research to facilitate readers’ integration of multiple texts. The three components are: (1) identifying and learning important information, (2) monitoring, and (3) evaluating. Afflerbach and Cho (2009) contend that strategies specifically addressing these three components may increase the generation of cross-text inferences.

Britt and Sommer (2004) studied how instructing students to integrate, and providing an intervening task, impacted how readers processed multiple texts. Undergraduate students in this research read two short history texts and were assigned to one of five conditions. Participants were delivered either instruction to integrate the texts or instruction to comprehend. Participants delivered the comprehension instructions were given “standard comprehension instructions with the goal of later answering general questions about the texts,” (p. 325) where participants in the integration condition were given instructions to “read two conflicting perspectives of a story, so they should compare and contrast the information provided by the two authors when learning the complete story” (p. 325). Participants were provided with an intervening task to complete after reading the first text and before beginning the second. The task consisted of either five macro-structure questions or five micro-structure questions. The macro-structure questions were short-answer “why and what happened questions” (p. 326, emphasis theirs), while the micro-structure questions requested recall of specific details from the text such as “how many” (p. 326). The fifth group was a control group that read only a single, fully integrated text without either instructions or a task.
After reading, participants completed four posttest measures: two measures of comprehension (recognition and recall), and two measures of integration (forced-choice timeline task and free recall switches between texts).

Britt and Sommer (2004) set forth the Restructuring Hypothesis to support the expectation that both instruction to integrate and macro-level questions “will lead to a more durable, well-structured representation” (p. 321) resulting in improved integration of the texts. Specifically, instruction to integrate will allow students to “intentionally structure their initial text representation for integration” (p. 321), while providing macro-structure questions after reading the first text will help students “create an efficient structure” (p. 321).

In the analyses, Britt and Sommer removed participants who completed less than half of the items on the intervening task. This resulted in nine participants’ removal (out of 145 total participants) from the analyses. Further explanation why these participants were removed, and the effect of their removal on the results was not provided.

Participants who were instructed to comprehend scored higher than those instructed to integrate on a recognition comprehension posttest. There was not a significant difference between different types of intervening tasks. Participants given macro-structure questions scored higher than those given micro-structure questions on the measure of recall comprehension. The participants given micro-structure questions performed significantly lower than those given the single integrated text (i.e., the control). There was no effect of instruction on recall comprehension. On an integration posttest measure assessing the order from which participants place timeline events from two separate texts, Britt and Sommer (2004) contend “a marginal effect of reading instruction” (i.e., \( p = .085 \), p. 330) where participants given integration instructions outperformed participants given comprehension instructions. There was no effect of intervening task on the timeline ordering measure of integration. The second measure of integration assessed responses to the free recall measure. Participants who generated more switches or transitions between texts in the free recall were considered to have a more integrated representation. The maximum number of transitions was fifteen. These transitions were present in the text read by the control group (i.e., an already synthesized, fully-integrated, text). There was no effect of instruction on number of transitions. Only participants given macro-structure questions (M = 2.35) had significantly more integrated recalls than micro-structure questions (M = 1.66). Participants in the single-text condition (M = 3.40) had significantly more transitions than those receiving micro-structure questions.
The results from Britt and Sommer (2004) reveal a number of important findings. First, participants given instruction to integrate prior to reading multiple texts, despite one marginal result, did not score significantly higher than participants given instruction to comprehend on measures of integration. Participants who were given instructions to comprehend did, however, score higher on one measure of comprehension than participants given instructions to integrate. These findings suggest that just telling readers to integrate two texts does not result in significantly greater performance on integration measures than readers told to comprehend two texts. Despite the expectations set forth by the restructuring hypothesis, it seems as if more assistance is necessary to influence readers’ structuring of texts. Second, the intervening task was a set of five questions focusing on either the macro- or micro-structure of the first text. This type of task did have an impact on one measure of each comprehension and integration. A task that focused on developing detailed knowledge from the text helped improve comprehension but hindered integration when compared to a task that focused on developing a coherent comprehensive representation of the texts.

Firetto and Van Meter (2008; 2012) also tested the impact of instructions on comprehension and integration. Participants were provided with either instructions to integrate or instructions to comprehend prior to participants’ reading a pair of texts. They were also assigned to a text type condition (i.e., in a 2 x 2 design). Texts were manipulated to have explicit overlap or implied overlap. There was not a significant difference for type of instruction on either comprehension or integration posttests; however, participants given texts with explicit overlap performed higher on the measure of integration.

**Fidelity of the integration interventions.**

Of the research presented thus far, there is not a consistent and clear path toward understanding which tasks improve readers’ integration of multiple texts. Much of the research presented has not ensured that interventions are implemented with fidelity. The central purpose of treatment fidelity, or treatment integrity, is to ensure that the intervention was implemented as effectively as possible. Without ensuring an interventions’ fidelity, the possibility that other variables are responsible for the results is introduced (Kazdin, 1986; Moncher & Printz, 1991; Sechrest &
Yeaton, 1981). In the research presented here, it is critical to ensure that any intervention to prompt integration is actually responsible for the changes in integration; this can be achieved by verifying treatment fidelity.

Regardless of whether all participants were delivered the exact same intervention, the need to address how they receive the treatment is critical. Due to individual differences (e.g., reading level, attention, prior knowledge, etc.), it is important to verify that the experience received by participants is consistent with the experience delivered by the researchers. With respect to research on integration, in Britt and Sommer’s (2004) study, where students reading two texts were given both instructions and an intervening task to facilitate integration, participants who did not correctly complete 50% of the macro- or micro-structure questions on the intervening task were removed from the analyses.

This author believes that one possible reason for the elimination of the data from these participants relates to the issue of treatment fidelity. If a participant did not do the macro-structure questions (e.g., left the questions blank) and yielded a high integration score on the posttest, the interpretation of the results would suggest that the increase in score was due to being provided with macro-structure questions. Because that participant did not do the macro-structure questions, some other factor would likely be responsible for the high integration scores. By verifying that all participants did the questions (i.e., removing participants who did not meet the 50% correct threshold), Britt and Sommer (2004) are ensuring treatment fidelity of their intervening task, and increasing the likelihood that correct completion of the intervention questions are the factor responsible for changes in the dependent measures of integration and comprehension. Unfortunately, the paper does not report whether the pattern of results pertaining to the intervening task was also found on analyses of all participants, or if the effect of intervening task was only evident when accounting for participants correctly completed at least 50% of the task. Of additional concern is the bias that may have resulted from removing participants from the intervening conditions without removing a comparable group from the control group. Comparisons between the intervening task conditions and the control group, who had no corresponding fidelity measure, may be flawed.

Furthermore, only the fidelity of the intervening task was accounted for—there was no fidelity consideration for the delivery of the instructions. Correctly responding to the intervening task did not require any knowledge of the instructions. It is not clear whether the failure to detect significant differences on the measures based on the instructions were due to the instructions, or whether the participants failed to attend to them. This is of particular
concern because it was already evident that some of the participants were unable to adequately complete the intervening task. Because failure to ensure treatment fidelity may result in low power due to a decreased treatment effect size and an increase in type II error (DiGenerro, Martens, & Kleinmann, 2007; Smith & Glass, 1977), it is possible that absence of treatment fidelity for Britt and Sommer's (2004) instruction task was a factor in why there was not a statistically significant effect on posttest measures of integration.

**Tying it all Together**

Because college students in introductory biology courses often learn from the textbook, and thus experience an environment similar to that of multiple texts, drawing from the literature may help to aid these students’ conceptual integration. To achieve this, the use of strategies and tasks may be necessary to support students in generating the connections between texts. However, there is evidence that some readers are more able to integrate than others. We should first explore those conditions more systematically, given the resource investments necessary to design, test, and deliver instructional interventions. There is a need for a pragmatic approach to support integration between multiple texts and to find conditions that are both necessary and sufficient for integration.

The poor efforts to address treatment fidelity in some studies, as well as the examination of naturally-occurring reading processes in other studies, leaves open the question, “Could readers effectively integrate texts if they were aware that they should integrate – is it enough to know?” Although there is little reason to be optimistic that knowing is both necessary and sufficient for readers to integrate, there is also little reason to assume that it is not. Studies 1 and 2 provide a direct test of this hypothesis.

Even if readers are aware that two texts should be integrated, it is unclear that these readers would understand what these instructions mean. That is, for a reader whose experiences have been primarily limited to single-text comprehension, it is not clear how that reader would interpret instructions directing them to draw connections between texts. Accordingly, we must ask, “Could readers effectively integrate texts if they understand what the task of integration means?” Experiment 2 tests this hypothesis by not only including instructions to integrate but also by taking steps to ensure that these instructions are understood.
Finally, although *knowing* and *understanding* are likely both necessary for text integration to occur, these conditions will not be sufficient if readers do not know how to *accomplish* integration. Alexander (2003) describes novice learners as “need[ing] explicit instruction on *how* [emphasis added] to be strategic” (p. 12). Experiment 3, tests this hypothesis, through an intervention designed to provide the necessary support and guidance. The integration intervention provides support through aiding readers’ selection of relevant content, emphasizing readers’ associations between this content, and regulating readers toward a goal of integration. This intervention is compared against an intervention aimed at enhancing comprehension and a control task.

The next chapter presents findings from Experiments 1 and 2, which tests the *know* and *understand* hypotheses. As expected, the results from these studies suggested that readers require more support. Chapter 4, presents findings from Experiments 3a and 3b, and tests an intervention developed support readers’ efforts to integrate.
Chapter 3

Experiment 1

The goal of Experiment 1 was to determine if instructing college students to integrate influenced their integration of two texts. While the goal of the experiment was to assess integration, it was also critical to measure readers’ comprehension. Comprehension was assessed for two purposes. First, it was important to ensure that students’ efforts to integrate the texts did not harm their basic comprehension of the texts. If the readers’ focused exclusively on generating connections, thus causing participants’ comprehension of the individual texts to decline, that would be an undesirable consequence. Furthermore, single-text comprehension was measured to determine if both texts were understood. If the texts were not comprehended, it is unlikely participants would be able to draw connections between them. The focus of Experiment 1 was to assessing the effect of task instructions given to participants prior to reading two independent, but related, texts. Participants were assigned to one of two task instruction conditions and one of two text order conditions.

After reading the instructions, participants were asked to verify that they had knowledge of the assigned task by reiterating the instructions. The purpose of the verification task was to ensure participants had read the instructions. If participants were unable to recall the instructions, attributing any change in the dependent measures due to the instructions would be faulty. After reading both texts, participants completed three posttests: two that assessed comprehension of individual texts and one that assessed integration. This experiment primarily focused on addressing whether having knowledge that one should integrate texts was sufficient to increase readers’ integration of those texts. The research questions below were addressed.

1) Success of Instruction Delivery
   a. Are college students able to recall the instructions delivered as part of an experimental manipulation?
   b. Is there a difference in college students’ ability to recall instructions when those instructions differ across conditions?

2) Effects of Task Instructions on Single-Text Comprehension
   a. Do college students delivered task instructions to comprehend outperform students delivered task instructions to integrate on measures of single-text comprehension?

3) Effects of Task Instructions on Multiple-Text Integration
   a. Do college students delivered task instructions to integrate outperform students delivered task instructions to comprehend on a measure of multiple-text integration?
4) Relationship between Need for Cognition and Integration
   a. Is there a relationship between Need for Cognition and performance on comprehension and integration measures?
   b. Does Need for Cognition moderate the effect of task instructions on integration?

Method

Participants.

Participants were 318 students (244 female) recruited from three lecture sections of a biology course on mammalian anatomy. The course was a large introductory lecture and lab course for students in life sciences majors at The Pennsylvania State University during spring semester of 2012. Participants ranged in age from 18 to 34, with the majority of participants being 18 (14.2%), 19 (42.1%), 20 (66.4%), 21 (17.9%), or 22 (11.3%). The majority of participants identified as White (84%), with the remaining participants identifying as American Indian (0.3%), Asian (4.7%), Black (5.0%), and Hispanic (3.1%). Several participants indicated race as “other” (1.9%) or did not respond (0.3%). Participants represented a range of semester standing: freshman (0 – 1 completed semesters; 25.9%), sophomore (3 – 4 completed semesters; 27.8%), junior (5 – 6 completed semesters; 22.1%), senior (7 – 8 completed semesters; 17.3%), and greater (9 – 15 completed semesters; 1.2%). Grade point average (GPA) ranged from 1.9 to 4.0 with a mean GPA of 3.32 (SD = 0.41). Approximately half of participants reported being in a biology-related major (51.9%), and the other half reported enrollment in a major that was not biology-related (48.1%). All participants implied consent. [See Appendix A for a copy of the Implied Consent Document.]

Design.

Participants were randomly assigned to one of four conditions in a 2 x 2 design: Text Order (endocrine first vs. urinary first) x Task Instructions (read to comprehend vs. read to integrate). Two individual difference measures assessed biology prior knowledge and Need for Cognition. Two dependent measures assessed single-text comprehension (i.e., small-grain text comprehension and large-grain text comprehension) and one dependent measure assessed text integration.
Materials.

**Individual difference measures.**

*Demographics.* The demographic survey included questions on age, gender, race, semesters completed, grade point average, and current major. [See Appendix A for a copy of the demographics questions.]

*Biology prior knowledge (BPK).* The 10-item, multiple-choice biology prior knowledge measure was based on a selection of items from a biology content knowledge assessment used by The Education Testing Service (ETS; 2011). The author consulted with a biology expert and selected ten items with content related, or relevant, to the current study. Four items required interpretation of graphs or charts, and six items were text-only. Permission was granted to use the selected items from the copyrighted materials on February 15, 2012.

Participants were told that they may be asked questions containing content that they have not yet learned, and that they were to select the best choice. Items were delivered in the same order as the ETS document. All items were presented on a single page. Participants who skipped any items were reminded to complete them before submission. The total number of correct items on the biology prior knowledge test provided a measure of prior content knowledge in biology; scores had a possible range from 0 to 10. The measure of internal consistency was $\alpha = .474$. [See Appendix A for a copy of the biology prior knowledge measure.]

*Need for Cognition (NFC).* Need for Cognition assesses the degree to which individuals enjoy engaging in activities that require thinking (Cacioppo & Petty, 1982). Participants completed the short, 18-item version of the Need for Cognition measure, which included statements such as “I prefer complex to simple problems,” “I prefer my life to be filled with puzzles I must solve,” and “I find satisfaction in deliberating hard and for long hours.” Half of the statements on this scale were reverse coded, such as “Thinking is not my idea of fun” and “I only think as hard as I have to” (Cacioppo, Petty, & Kao, 1984). Participants responded to each statement on a 5-point likert-scale. For each statement, participants dragged a slider along a scale from 1, “Not at all like me”, to 5, “Just like me”. Initially, the sliders were all positioned at the middle point (i.e., 3, “Somewhat like me”). Once participants moved each slider, a number that corresponded to its position appeared on the right. High scores indicated higher Need for Cognition (after reverse coding).
This measure was implemented according to Cacioppo et al. (1984) with the additional provision that participants were also informed that there was not a correct or incorrect response (Cacioppo & Petty, 1982). Instructions were provided on the top of the page along with the numerical scale and corresponding verbal descriptions; all statements were presented on one page, and statement order was not randomized. Upon submission of the measure, participants who failed to respond to all 18 statements were prompted to indicate a response for the missing item(s). Participants’ responses were calculated by averaging the ratings of all statements after reverse coding. Possible scores could range from 1 to 5, \( \alpha = .880 \). [See Appendix A for a copy of the Need for Cognition measure.]

**Experimental text(s).**

Participants read two separate texts. Each text covered a different biological system: the endocrine system and the urinary system. Both texts were developed by the author and a biology expert. The informational texts began as excerpts from an Anatomy & Physiology textbook (Saladin, 2010), but were modified to remove extraneous information and increase clarity. The endocrine text was 1780 words in length and had a Flesch Reading Ease of 36.4 and a Flesch-Kincaid Grade Level of 12.9. The urinary text was 1702 words and had a Flesch Reading Ease of 47.9 and a Flesch-Kincaid Grade Level of 11.5. Each text was supplemented with 6 visual representations (e.g., illustrated cross sections of the kidney depicting major structures; diagrams of the chemical structures of a steroid, a monoamine, and a peptide) that were referenced and discussed within the text. Text order was counterbalanced so that half of the participants read the endocrine system text first (endocrine first condition) and half read the urinary system text first (urinary first condition). Qualtrics recorded time on the webpage for each text. [See Appendix A for a copy of both the endocrine system text and the urinary system text.]

**Knowledge measures.**

**Task instructions verification.** Passively delivering task instructions does not ensure that participants actually attend to the instructions delivered. To ensure that participants had knowledge of their assigned task instructions, a task instructions verification measure was included. This measure asked participants to “repeat the
instructions you were just given and describe them with as much detail as possible. Participants typed their recollection of the task instructions into an open-ended textbox immediately after the task instruction was delivered. Participants were not forewarned of this question. The inclusion of task instructions verification provided a method of assessing whether participants were aware of the delivered task instructions for their respective condition.

Two raters, the first author and a graduate student in educational psychology, scored all responses to determine if participants had knowledge of the instruction that was delivered. Scoring was dichotomous and indicated whether a participant was able to report the delivered instructions or not (yes = 1; no = 0). The scoring rubric was sensitive to condition, so that participants who received instructions to integrate were required to recall the need to integrate, whereas participants who received instructions to comprehend were required to recall the need to comprehend. [See Appendix A for a copy of the rubric used for scoring the responses.] Examples of responses and their coding are presented in Table 3.1. Both raters scored 10% of the responses and inter-rater agreement was 91%. Disagreements were resolved through discussion, and the first author coded the remaining responses.

Table 3.1

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<tbody>
<tr>
<td>Instructions to Comprehend</td>
<td>- Read both texts and read them carefully as if I am studying for one of my biology exams. There will be two texts and each covers a lot of material from biology.</td>
</tr>
<tr>
<td></td>
<td>- Read and comprehend each subject</td>
</tr>
<tr>
<td></td>
<td>- Two biology texts will be given to read and questions regarding their concepts will be asked at the end. They suggest reading them together and combining the ideas represented in both to gain a full understanding of the material.</td>
</tr>
<tr>
<td></td>
<td>- Have to combine the information read in both texts.</td>
</tr>
<tr>
<td>Instructions to Integrate</td>
<td>- Please read the following text as if you were studying for a test. Answer the questions that follow. You may be able to learn more than you knew.</td>
</tr>
<tr>
<td></td>
<td>- Please read carefully.</td>
</tr>
</tbody>
</table>

**Single-text comprehension.**

**Small-grain text comprehension: Sentence verification technique.** For each informational text, a 16-item Sentence Verification Technique (SVT) comprehension measure was constructed according to Royer’s (1990) specifications. This measure assessed the small-grain comprehension of each text. This technique consisted of presenting a series of individual sentences and, for each sentence, participants determined whether or not the
sentence had the same meaning as a sentence that appeared in the text. A participant marked “Yes” if the sentence has the same meaning as a sentence from the text and “No” if the sentence had a different meaning. For each informational text, the 16-item SVT measure was composed of 12 sentences from the text and four distractor sentences not from the text. The 12 sentences were selected from various locations throughout the text. There was no more than one sentence from a single paragraph and each sentence contained specific content information (i.e., transition sentences were excluded). For each of the 12 sentences, paraphrase and meaning change versions were constructed. Paraphrase sentences were composed by replacing the original words in the sentence with synonyms while rearranging phrases to create an altered version of the sentence with the same meaning. Meaning change sentences were constructed by altering a word, or words, to change a critical part of the sentence thus changing the overall meaning. One version of each sentence was used in the measure. Table 3.2 contains a sample of an original sentence from the text and the corresponding paraphrase and meaning change sentences for both texts.

Table 3.2
Sample of two original sentences with corresponding paraphrase and meaning change constructed sentences for the SVT measure

<table>
<thead>
<tr>
<th></th>
<th>Endocrine</th>
<th>Urinary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>Even very simple organisms composed of only a few cells have mechanisms for intercellular communication, suggesting that such mechanisms evolved very early in the history of life.</td>
<td>It would be impossible to excrete metabolic waste or maintain a healthy blood pressure, salt balance, and water balance without the urinary system.</td>
</tr>
<tr>
<td>Paraphrase</td>
<td>Organisms composed of only a few cells have mechanisms for intercellular communication, indicating that early in the history of life these mechanisms had evolved in very simple organisms.</td>
<td>It is only by the work of the urinary system that our bodies can excrete metabolic waste or maintain a healthy blood pressure, and salt and water balance.*</td>
</tr>
<tr>
<td>Meaning Change</td>
<td>Even very simple organisms composed of only a few cells have mechanisms for hypophyseal communication, suggesting that such mechanisms evolved very early in the history of life.*</td>
<td>It would be slower to excrete metabolic waste or maintain a healthy blood pressure, salt balance, and water balance without the urinary system.</td>
</tr>
</tbody>
</table>

Note: underline emphasis added for clarity and was not present in measure. *Indicates version of sentence selected and present in measure.

Finally, four distractor sentences (i.e., syntactically similar sentences with content not covered in the text) were constructed. An example distractor for the endocrine text was, “Melatonin, a monoamine, is synthesized from serotonin during the night, and its secretion fluctuates seasonally.” Despite the mention of the term “monoamine”, content pertaining to melatonin was not included in the endocrine text; additionally, the text did not cover serotonin, hormones’ impact on sleep, or any hormone that fluctuated seasonally. A distractor for the urinary text was, “The pH of urine ranges from 4.5 to 8.2 but is usually about 6.0 and is mildly acidic.” Again, while the concept of “urine”
was covered in the text, there was no information provided regarding specific characteristics of urine, such as the pH or acidity. A biology expert reviewed all final items and confirmed accuracy to ensure that a translation error was not made, particularly for paraphrase and meaning change items. Both SVT measures contained four original sentences and four paraphrase sentences, both coded as having the *same meaning*, along with four meaning change sentences and four distractor sentences, both coded as having a *different meaning*.

The sentence verification measure was completed immediately after reading the corresponding text. Participants were presented with one item at a time in two sets of eight items. For both texts, the first set of eight items was composed of the six sentences selected from the first half of the text and two distractors. The second set of eight items was composed of the six sentences selected from the second half of the text and two distractors. Within each set, item order was randomized. This separation of sets was done to ensure that random presentation would not result in a participant receiving a sentence from the end of text immediately after finishing the text and is consistent with Royer’s (1990) implementation.

Participants responded to the question, “Was this sentence from the text?” Responses were scored as correct if original and paraphrase sentences were marked as “Yes,” and if meaning change and distractor sentences were marked as “No”. The maximum possible score for each measure was 16, and the minimum was 0. Internal consistency of the endocrine system SVT was $\alpha = .468$, and internal consistency of the urinary system SVT was $\alpha = .494$. This was considered to be a measure of small-grain comprehension because correctly responding to an item required attention to nuanced, sentence-level detail. [See Appendix A for a copy of each SVT test.]

*Large-grain text comprehension: Principle identification technique.* A 4-item Principle Identification Technique (PIT) large-grain comprehension measure was constructed according to Royer’s (1990) specifications for both the endocrine system and the urinary system. For each measure, participants were instructed to think about the respective text and “judge whether or not the concept or principle… is related or similar” to the text. Participants were given four scenarios and responded dichotomously (“Yes”; “No”) to each scenario. The order of the scenarios were randomized, with all four presented on the same page. Participants received the PIT measures in the same order of the texts, as per their condition (i.e., urinary first condition received the urinary system PIT measure prior to the endocrine system PIT measure).

For each text, a central principle was determined. Scenarios were developed in a 2 x 2 format according to two facets: surface structure and deep structure. Deep structure scenarios compared the underlying principal(s) of
the text, while surface structure scenarios considered superficial characteristics. Because, the deep structure of the endocrine text was the method of communication and the deep structure of the urinary text was the process of filtration, the two scenarios that were created to have the *same* deep structure referred to these same concepts (i.e., communication/filtration). For each measure, two scenarios had the *same* surface structure (i.e., from the field of biology), while two scenarios had *different* surface structures (i.e., outside of the field of biology). The four scenario items were developed in a 2 x 2 format (i.e., same surface/same deep; same surface/different deep; different surface/same deep; different surface/different deep). For example, consider the endocrine system scenario for different surface but same deep structure:

A New York City Law office is sending a package to two local clients. One intern is sent to walk over to the building next door and deliver the first package. He enters the building, takes the elevator, and rings the doorbell until the client opens the door and signs for the package. The second intern is sent out on bicycle to deliver that client’s package a block away. When she arrives at the recipient's building, the security guard will not let her in with the bicycle, so the guard signs for the package and delivers it to the recipient. The law office is pleased that both clients received the packages at nearly the same time.

While the surface structure is different (i.e., outside of biology), the deep structure of the scenario is the same as that presented in the endocrine system text. The transportation of the chemical messages of different hormones closely matches the two forms of package delivery described in the scenario. For the urinary text, consider a different scenario, this item has the same surface structure, but a different deep structure:

On Francine’s 30th birthday she noticed a “floater” in her vision. Confused as to why she was seeing them for the first time, she went to the eye doctor concerned. Her eye doctor assured her she was fine, but checked to be sure the retina was not detached. After ensuring her retina had not detached from the tissue, he began to describe the jelly-like fluid in the eyes called vitreous. He told her that as she grows older the fluid thickens causing small particles in her eye to become more visible. The small spots and “floaters” that she sees are harmless and would likely not cause any future vision problems.

The surface here is the same (i.e., biology-related), but the deep structure is entirely different from that presented in the urinary system text. The process of developing and diagnosing the floaters does not compare to any of the processes from the urinary system, and in particular, it does not involve a filtration process.

The measure assessed whether participants could identify the global principle of the text and thus it was used to assess large-grain comprehension. Responses to scenarios that had the same deep structure (irrespective of surface structure) with “Yes”, and those with different deep structure with “No”, were coded as correct. For each text, the correct responses to scenarios received one point. The maximum possible total score was 4, and the minimum possible score was 0. The internal consistencies were unacceptably low¹: endocrine system $\alpha = .080$, urinary system $\alpha = -.019$. [See Appendix A for a copy of both PIT measures.]
**Multiple-text integration.**

**Small-grain integration: Inference verification technique.** A 20-item Inference Verification Technique (IVT) measure was constructed according to Royer’s (1990) specifications to assess text integration. Participants were shown a series of sentences and instructed to indicate if each sentence could be “reasonably inferred from the biology material” or if it was a “logical (true) conclusion based on the information presented . . . even if it was never explicitly stated.” Participants were presented with 20 sentences; for each sentence they were directed to mark “Yes” if it could be inferred from the materials, or “No” if it could not be inferred from the materials. The author, in conjunction with a biology expert, developed 10 true inference statements that connected information between the endocrine system and the urinary system. The false inference statements were generated by the author and confirmed by the biology expert as false. See Table 3.3 for an example of a true and false inference with corresponding text excerpts.

Table 3.3

*Example of Inference Verification Technique (IVT) item with text excerpts*

<table>
<thead>
<tr>
<th>Text Excerpts</th>
<th>Inference Verification Item</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>True Inference Example</strong></td>
<td></td>
</tr>
<tr>
<td>Transport proteins not only enable hydrophobic hormones to travel in the blood, but also prolong their half-lives. (Endocrine System)</td>
<td>Transport proteins not only enable hydrophobic hormones to stay in the blood longer, but also prolong their half-lives / because large proteins like these are not filtered out of the glomerulus and flow instead into the efferent arteriole.</td>
</tr>
<tr>
<td>Most of the blood, including large proteins and other molecules, is not filtered at all, and flows instead into the efferent arteriole. (Urinary System)</td>
<td></td>
</tr>
<tr>
<td><strong>False Inference Example</strong></td>
<td></td>
</tr>
<tr>
<td>Blood vessels come into contact with every part of the nephron and allow water and solutes to pass between the blood and the fluid in the nephron. (Urinary System)</td>
<td>Blood vessels come into contact with every part of the nephron, allowing water and solutes to pass between the blood and the fluid / for cells that have receptors for them.</td>
</tr>
<tr>
<td>Hormones stimulate only those cells that have receptors for them. (Endocrine System)</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* “/” added for clarity to convey the separation between text excerpts and was not presented in the measure.

This measure assessed participants’ integration between the two systems on a very detailed level. Correct endorsement to an item required attention to specific parts of both texts and the ability to understand if they were connected. Therefore, the Inference Verification Technique (IVT) measure was considered a measure of small-grain integration. Participants were presented with one item at a time and item order was randomized. Responses to true inferences with “Yes”, and false inferences with “No”, were correct. Each correct response received one point. The
maximum possible total score was 20, and the minimum possible was 0. The internal consistency of the scores for the Inference Verification Technique was low\(^1\), \(\alpha = .181\). [See Appendix A for a copy of the IVT measure.]

**Open-ended comments (optional).**

An optional open-ended comments box was included at the end of the experiment to allow participants to respond with any comments or concerns. This was included to gain descriptive insight from students, identify technical issues, or recognize other unforeseen problems. Only approximately 10% of the participants chose to enter a response.

**Independent variable.**

*Task instructions.* Participants were delivered one of two types of task instructions. Students were presented with either a *read to comprehend* (RTC) task, where students were told to read each text with the purpose of comprehension, or a *read to integrate* (RTI) task, where participants were told to read to integrate, or connect, the two texts. Participants delivered the RTC task read instructions stating:

INSTRUCTIONS: READ CAREFULLY
You will be asked to read two different biology texts, read each one as if you were studying for a test in your course. Each text has a number of biology concepts that are covered. While you are reading each text, try to study the concepts and comprehend each one to the best of your ability.

Research has shown that if you *read each text carefully* you may be able to learn more than if you didn’t.

Participants delivered the RTI task read instructions stating:

INSTRUCTIONS: READ CAREFULLY
You will be asked to read two different biology texts, read both as if you were studying for a test in your course. Both texts have a number of biology concepts that can be related to the other text. While you are reading the texts, try to study how the concepts in one text are connected to the concepts in the other.

Research has shown that if you can combine the information in both texts while you are reading, you may be able to learn more than if you didn’t.
Instructions were constructed to be parallel, but with different core tasks, either one of comprehension or one of integration. The RTC instructions contained 80 words, and the RTI instructions contained 93 words. Qualtrics recorded time spent on the instructions page.

Procedures.

All participants were recruited from the biology course when the author attended a class lecture. During recruitment, students in the class were informed that participation in the study would entail reading biology text and answering questions. They were also notified that it would take approximately one hour to complete the research. All study materials were accessed through a link posted on the course Angel website, including the implied informed consent document. Participants were not able to access experimental materials until after giving consent. All participants received extra credit toward their course grade.

Experimental materials were delivered via Qualtrics and participants were able to complete the materials at a time and location of their choosing. Participants were given five days to complete the experiment, but they were required to complete all materials in one session. Qualtrics randomly assigned participants to the task instructions condition and counterbalanced text order. Upon first opening the survey, participants were instructed to “Please read all instructions very carefully!” They were then thanked for participating in the research and reminded that completion would take approximately one hour. Students received the materials in the following order: demographics, biology prior knowledge measure, Need for Cognition measure, task instructions (as per condition assignment), task instructions verification, first text (as per condition), SVT measure for first text, second text (as per condition), SVT measure for second text, IVT measure, PIT measure for first text, PIT measure for second text, and open-ended comments. Qualtrics did not permit participants to go back to pages once they were submitted, and the back button of the browser was disabled. Table 3.4 displays the measures in order for both of the conditions.
Table 3. 4

Order of measures and procedures for both RTC and RTI conditions in Experiment 1

<table>
<thead>
<tr>
<th>Measure</th>
<th>RTC</th>
<th>RTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Demographics</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Prior Knowledge</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Need For Cognition</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Task Instructions</td>
<td>Read to Comprehend</td>
<td>Read to Integrate</td>
</tr>
<tr>
<td>Task Instructions Verification</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Informational Text</td>
<td>Endocrine &amp; Urinary</td>
<td>Endocrine &amp; Urinary</td>
</tr>
<tr>
<td></td>
<td>Counterbalanced</td>
<td>Counterbalanced</td>
</tr>
<tr>
<td>Sentence Verification Technique</td>
<td>Endocrine &amp; Urinary</td>
<td>Endocrine &amp; Urinary</td>
</tr>
<tr>
<td></td>
<td>Immediately After Each Text</td>
<td>Immediately After Each Text</td>
</tr>
<tr>
<td>Inference Verification</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Principle Identification</td>
<td>Endocrine &amp; Urinary</td>
<td>Endocrine &amp; Urinary</td>
</tr>
<tr>
<td>Technique</td>
<td>Same as Text Order</td>
<td>Same as Text Order</td>
</tr>
<tr>
<td>Open-Ended Comments</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Results and Discussion

Preliminary analysis.

Descriptive statistics are presented in Table 3.5. For clarity, measures are divided into demographics, individual difference measures, and dependent measures and are presented for each of the four conditions.
Skewness and kurtosis statistics were assessed for all dependent measures; all measures were approximately normal, except for the two PIT measures, which were strongly negatively skewed. Item analysis was conducted via CTTITEM (Lei & Wu, 2007) on each of the dependent measures. Because the PIT measures both had unacceptably low reliability, a non-normal distribution, and item analysis revealed low item discrimination and difficulty values, these two measures were excluded from further analyses in Experiment 1.

Time. Qualtrics recorded time spent on the page that delivered the task instructions and each of pages presenting the texts. For each of these, time ranges varied widely and the distributions were positively skewed. Time spent on the page delivering the task instructions ranged from 0.4 seconds to 32.5 hours. For the endocrine system text, time ranged from 0.1 seconds to 7.8 hours; for the urinary system text, time ranged from 1.3 seconds to 1.6 hours. See the histograms for time spent on the task instructions (Figure 3.1), on the endocrine text (Figure 3.2), and on the urinary text (Figure 3.3). For each of the histograms, condition assignment for task instructions is indicated. Statistical outliers were removed using the outlier labeling rule with $g = 2.2$ (Hoaglin & Iglewicz, 1987). These outliers are removed only in the figures and means presented as part of the time analysis presented here. These outliers were removed because the purpose of this analysis was to determine if participants spent a reasonable amount of time on the instructional activities and compare the times between conditions. Including the outliers distorted the time data, whereas removing the outliers provided a more representative mean for the condition effects.
After removal of the outliers, the mean time spent on the page delivering the task instructions was 12.6 seconds on the task instructions. On average, participants spent 6.3 minutes on the endocrine text (1780 words) and 4.83 minutes on the urinary text (1702 words).

*Figure 3.1* Time spent on instruction for participants in both read to comprehend (RTC) and read to integrate (RTI) conditions. *Nineteen outliers removed.*

*Figure 3.2* Time spent on endocrine text for participants in both read to comprehend (RTC) and read to integrate (RTI) conditions. *Twelve outliers removed.*
Figure 3.3 Time spent on endocrine text for participants in both read to comprehend (RTC) and read to integrate (RTI) conditions. *Twelve outliers removed.

Because, participants completed the study at a location of their choosing (e.g., at home, in the library, etc.), the skewed distribution and large number of statistical outliers may be due, in part, to various forms of distractions (e.g., pausing to take a phone call or watch television). Of additional concern is the large number of participants who devoted little time to reading the task instructions and to learning the material. This may be due to the difficulty perception of the texts. Twelve participants voluntarily reported in the open-ended comments that they perceived the texts as either too long, too hard, or too dense; one participant even admitted to “skim[ming] instead of read[ing]”. If participants failed to read the materials, or were distracted while reading, it could not be expected that participants would comprehend or integrate successfully.

**Condition effect on the recall of task instructions.**

After being delivered the task instructions, participants were asked to report what they remembered by re-typing them into an open-ended textbox. The responses were coded as to whether they had recognized the main point of the task instructions (i.e., “reading” or “comprehending the texts” for the RTC participants; “integrating” or “connecting the texts” for the RTI participants). Many participants were unable to successfully report knowledge of the task instructions immediately after instructions were delivered. As a whole, 68% of the participants were able report knowledge of the task instructions: 82% of the RTC condition and 53% of the RTI condition.
The variety of responses for students unable to report the task ranged widely. Three students explained that they had “accidentally” clicked past the task instructions. Other participants left the text box blank, reported detailed descriptions of instructions of the NFC or prior knowledge measures, and other various responses (e.g., “I was not paying attention”, “i didnt read it. lol [sic], and “I actually didnt read it, I figured it just said answer the following questions. Sorry.” [sic]). Other participants recalled extraneous information from the instructions, without a description of the task instructions: “I will be given questions about biology,” “Please read the directions carefully,” and “Was supposed to make sure i read the instructions as if i was trying to study for a biology test. [sic]” Additionally, 46 participants in the RTI condition reported generic responses regarding reading (e.g., “read the text”). These participants were not able to verify the purpose of integration in their responses, and thus, were categorized as not being able to verify the task instructions.

One explanation for being unable to verify the task instructions is that some students may have skipped past (either purposely or accidentally) the page delivering the task instructions. This explanation is supported by the time data reported earlier (e.g., recorded times of less than one second). Due to the design of the experiment, once participants had progressed past page that delivered the task instructions, they were unable to go back to the page with the instructions. Even though all participants were delivered instructions, many never actually received them. Thus, differences respective to the task instructions condition on the posttest measures would not be expected for participants who never received the task instructions.

A Chi Square test measured the association between participants’ ability to recall the task instructions and the type of task instructions delivered. A significant association was found, $\chi^2(1, N = 318) = 28.402, p < .001$. Participants who were delivered the RTC task instructions were more likely to report knowledge of the delivered task instructions than participants who were delivered the RTI task instructions (See Table 3.6).

Table 3.6

<table>
<thead>
<tr>
<th>Task Instructions Verification</th>
<th>RTC</th>
<th>RTI</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Instructions</td>
<td>Yes</td>
<td>130</td>
<td>86</td>
</tr>
<tr>
<td>Verification</td>
<td>No</td>
<td>28</td>
<td>74</td>
</tr>
<tr>
<td>Total</td>
<td>158</td>
<td>160</td>
<td>318</td>
</tr>
</tbody>
</table>

The distribution of participants who failed to report knowledge of the task was uneven with respect to the task instructions. More of the students from the RTI condition failed to report knowledge of the task than from the
RTC condition. It is possible that, participants who received RTC instructions were able to *guess* that the purpose was to “read”, and were thus coded as having knowledge of the task. Participants in the RTI condition who *guessed* that the purpose was to “read” were not considered to have knowledge of the task.

**Effect of task instructions on single-text comprehension.**

**Small-grain comprehension.**

A MANCOVA, with the two SVT scores as the dependent variables and biology prior knowledge as the covariate assessed the impact of task instruction. Text order was also included as a variable in order to determine if the order of the texts had any effect on the dependent variables or if there was an interaction between text order and task instructions.

All assumptions were assessed and met. The correlation between biology prior knowledge and both SVT measures was significant, \(r = .175\) (endocrine) and \(r = .220\) (urinary), permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and no significant interactions were found. Levine’s homogeneity of variance was not significant, \(p = .196\) (endocrine) and \(p = .651\) (urinary), suggesting the variances for both dependent variables were equal. Box’s M was not significant, \(p = .771\), indicating the covariance matrices of the dependent variable are equal across groups, and as a result, Wilkes’ Lambda was interpreted.

There was not a significant interaction between text order and task instructions, \(F(2, 312) = 1.445, p = .237, \eta^2 = .009\), indicating that the effects of task instruction were consistent across both text orders on the SVT measure of comprehension. There was not a significant effect of text order, \(F(2, 312) = 0.201, p = .818, \eta^2 = .001\), demonstrating that participants who read the texts in different orders did not have different levels of comprehension. There was also not a significant effect of task instructions, \(F(2, 312) = 1.033, p = .357, \eta^2 = .007\), indicating that participants who were given RTC task instructions did not score significantly higher than participants given RTI task instructions on comprehension. These findings indicate that the task of directing college student readers’ attention to the relationship between texts does not harm small-grain comprehension relative to participants who were instructed to focus on single-text comprehension.
Because the reliabilities for the scores of the SVT measures were undesirably low, it is possible that the lack of significant findings with respect to the SVT measure is a result of the low reliability. Furthermore, the overall poor performance on both the endocrine system SVT (mean = 9.81, SD = 2.495) and the urinary system SVT (mean = 9.94, SD = 2.480) is of concern. Considering both measures contained 16 items, the average proportion correct was just over 60%. Royer, Green, and Sinatra (1987) suggest 65 - 85% as the ideal range for SVT measures. The low scores on the SVT measures may be a result of poor comprehension, resulting from not reading the material thoroughly.

**Effect of task instructions on multiple-text integration.**

**Small-grain integration.**

An ANCOVA, with biology prior knowledge as the covariate, assessed the impact of the task instructions on the IVT measure of multiple-text integration. Text order was again treated as an independent variable to determine if there was an interaction between the order that texts were presented and the task instruction that was delivered.

All assumptions were assessed and met. The correlation between biology prior knowledge and the IVT measure was significant, \( r = .219 \), permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variable and biology prior knowledge, and no significant interaction was found, \( p = .853 \). Levine’s homogeneity of variance was not significant, \( p = .780 \), indicating equality of variances for the IVT variable.

There was not a significant interaction between text order and task instructions, \( F(1, 313) = 1.064, p = .640, \eta^2 = .001 \), indicating that the effects of the task instructions were consistent across both text orders on the IVT measure. There was not a significant effect of text order, \( F(1, 313) = 1.549, p = .214, \eta^2 = .005 \), indicating that there was not a significant difference between participants who read the texts in different orders on the IVT measure. There was also not a significant effect of task instruction, \( F(1, 313) = 0.636, p = .426, \eta^2 = .002 \), indicating that there was not a significant difference between participants given RTC instructions and RTI instructions on the IVT.
measure. This finding suggests that directing college student readers’ attention to the relationship between texts is not sufficient to impact their integration of the texts on an IVT measure.

In order to fully test the hypothesis that RTI instruction would improve college students’ performance on this measure of multiple-text integration, a follow-up analysis was conducted for which only those participants who were able to report verification of the task instructions were included. For both the RTC and RTI conditions, participants who did not report knowledge of their respective task instructions were removed. This resulted in 130 remaining participants in the RTC condition and 86 remaining participants in the RTI condition. The resulting means and standard deviations for IVT scores are shown in Table 3.7.

### Table 3.7

*Means and standard deviations for the IVT scores for the subset of participants who reported knowledge of the task instructions condition*

<table>
<thead>
<tr>
<th>Read to Comprehend</th>
<th>Read to Integrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>End. First (n = 65)</td>
<td>Uri. First (n = 65)</td>
</tr>
<tr>
<td>IVT 11.89 (2.20)</td>
<td>12.12 (2.30)</td>
</tr>
</tbody>
</table>

A 2 x 2 ANCOVA assessed the effect of task instructions and text order on the IVT measure of integration. All assumptions were again assessed and met. The correlation between biology prior knowledge and the IVT measure was significant, $r = .250$, permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variable and biology prior knowledge, and no significant interaction was found, $p = .521$. Levine’s homogeneity of variance was not significant, $p = .336$, indicating equality of variances for the IVT variable.

As with the full sample of participants, there was not an interaction of text order and task instructions, $F(1, 215) = 0.015, p = .901, \eta^2 = .000$, nor a significant effect of text order, $F(1, 215) = 0.405, p = .525, \eta^2 = .002$. Finally, there were no significant differences between task instructions on the IVT measure when only participants who verified receipt of their respective task instructions were included in the analysis, $F(1, 215) = .465, p = .496, \eta^2 = .002$. This further supports the assertion that awareness that one should integrate texts is not sufficient to increase integration.

Like the SVT, the IVT also had low reliability of scores, and overall low performance (mean = 11.79, SD = 2.25). According to Royer (1990), sufficient reliability of scores should be obtained if the test is developed according to his specifications and enough items are included. In practice, however various studies (e.g., Wiley &
Voss, 1999) fail to report the reliability coefficients of the scores. Albeit higher than the reliability coefficients found in this study, other research using these measures have reported somewhat lower than desired reliability coefficients (SVT, $\alpha = .67$; IVT, $\alpha = .68$; Bråten, Strømsø, & Britt, 2009). As a result of the low reliability, it is possible that the effect of task instructions may have been masked.

**Relationship between task instructions, multiple-text integration, and Need for Cognition.**

Hierarchical multiple linear regression tested if Need for Cognition significantly predicted participants’ IVT scores, after removing the variance from both SVT measures. The assumption of homoscedasticity was met through visual inspections of the histogram, p-p plot, and scatterplot of the regression standardized residual. Tolerance was checked, and multicollinearity was not problematic. Need for Cognition accounted for unique variance in participants’ IVT scores after the variance for the SVT measures was removed (see Table 3.8). The finding that Need for Cognition is a significant predictor of IVT scores is noteworthy, as this suggests that some participants are more inclined to integrate multiple texts than others.

Table 3.8

*Regression table for need for cognition and the IVT measure* $p<.05$

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B$</th>
<th>$SE (B)$</th>
<th>$\beta$</th>
<th>$\Delta R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td>.175*</td>
</tr>
<tr>
<td>Endocrine SVT</td>
<td>.213</td>
<td>.050</td>
<td>.236*</td>
<td></td>
</tr>
<tr>
<td>Urinary SVT</td>
<td>.241</td>
<td>.050</td>
<td>.236*</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td>.023*</td>
</tr>
<tr>
<td>Endocrine SVT</td>
<td>.200</td>
<td>.050</td>
<td>.222*</td>
<td></td>
</tr>
<tr>
<td>Urinary SVT</td>
<td>.217</td>
<td>.050</td>
<td>.239*</td>
<td></td>
</tr>
<tr>
<td>Need For Cognition</td>
<td>.604</td>
<td>.203</td>
<td>.154*</td>
<td></td>
</tr>
</tbody>
</table>

A follow up analysis explored the possibility of NFC as a moderator of task instructions. Instructional task and the centered NFC scores were entered into Step 1, and the interaction term between the centered NFC score and task instructions was added to Step 2. The model with the interaction term, did not explain a significantly greater amount of variance, $\Delta R^2 = .000$, F Change(1, 314) = 0.138, $p = .711$, and the interaction between NFC and task
instructions was not significant, $\beta = -.029, t(314) = -.371, p = .711$. The analysis was replicated including only participants who successfully verified the task instructions, and the pattern of results was the same. The strength of the relationship between task instructions and the IVT measure was not different with respect to Need for Cognition.

Conclusion

The major finding of Experiment 1 was that participants’ Need for Cognition significantly predicted integration. Participants with high Need for Cognition outperformed participants with low need for cognition on the IVT measure of multiple-text integration. This finding suggests that participants who have a drive to learn and understand at a deeper level are better able to make connections between texts than participants who do not have this drive. Participants who were given instructions to integrate two texts did not score significantly different from participants who were told to comprehend on a measure of comprehension or a measure of integration. On one hand, this indicates that directing readers’ attention to the relationships between texts does not harm comprehension, but on the other hand, these findings also indicate that the delivery of instructions informing students to integrate two texts was not sufficient to improve readers’ scores on a measure of integration. This point is highlighted by the failure to find significant effects of instructions even when participants who did not attend closely to instructions were removed from the analysis.

The results of this study suggest that providing task instructions to students to integrate two texts is not sufficient to result in changes on measures of integration. This finding is consistent with the expectations that college students require greater support to integrate texts, beyond simply being told that integration should be done. The challenge of assessing this expectation, of course, is the difficulty inherent in testing a null hypothesis. This challenge was exacerbated in Experiment 1 due to the low reliability of scores found for the dependent measures. It is possible that the absence of an effect for task instructions on integration was due to the poor reliability of the scores on the IVT measure. This concern is lessened, as the reliability of the IVT scores was not so poor as to mask the results of the aforementioned regression analysis. Furthermore, inspection of the effect size of the effect of instruction on the integration measure (i.e. $\eta^2 = .002$) suggests that these differences are not meaningful. Experiment 2 examines these issues further with efforts to improve the reliability of scores for the measures and by exploring an enhanced version of the task instructions manipulation to ensure that participants understand the instructions.
Experiment 2

Experiment 2 continued to assess the effect of task instructions on multiple-text integration. A third form of task instructions was added, and a new variable, text type, compared two forms of text presentation: two separate texts, and a single, combined text. Because no effects were found for text order in Experiment 1, text order was replaced by text type. The two forms of task instructions used in Experiment 1 remained the same; a new form was added, which provided additional emphasis on participants’ understanding of the integration task. For the new condition, text type, half of the participants received the same two separate texts as presented in Experiment 1, but the other half of the participants received a single, combined text. This combined text condition permitted comparison of readers’ ability to integrate urinary and endocrine system knowledge when this information was presented either separately or together.

Experiment 1 tested whether telling students to integrate could stimulate integration in an ecologically valid environment. The results of that experiment suggest that students who were told to integrate did not perform any better on an integration outcome measure than those told to comprehend. However, those conclusions are tentative based on a number of limitations present in Experiment 1. Experiment 2 addresses those limitations, as well as the possibility that knowing to integrate is not sufficient to prompt integration.

Notable changes from Experiment 1 include: minor revisions to SVT measures; moderate revisions to IVT measure; and major revisions to PIT measures to address issues of low score reliability. Additionally, a new individual difference measure and a new measure of integration to assess large-grain integration between the two biology systems were included. While the IVT measure used in Experiment 1 was one of the more widely used measures of integration, the author felt it was important to consider ways of measuring a larger grain-size of integration, and two measures of large grain integration were added. Finally, the Test of Relational Reasoning (TORR; Alexander, Dumas, Fox, & Firetto, in prep) was added as an additional individual difference measure because of the expected association between relational reasoning and integration. The addition of dependent measures permitted a method of triangulation to better understand the impact of instructions on readers’ integration. Finally, Experiment 2 was administered in a computer laboratory to allow for greater control over how participants complete the experimental task. With an administrator present, the likelihood of participants being affected by distractions can be greatly reduced.
The focus of Experiment 2 was to assess the impact of three forms of delivered instructions and two text types on students’ ability to comprehend and integrate text(s). The research questions below were addressed.

1) Success of Task Instruction Delivery
   a. Are college students able to recall the instructions delivered as part of an experimental manipulation?
   b. Do college students delivered different task instructions accurately report them to the same degree across three different task instructions?

2) Effects of Task Instructions and Text Type on Single-text Comprehension
   a. Do college students delivered task instructions to comprehend outperform students delivered task instructions to integrate and students delivered task instructions to understanding integration on comprehension measures?
   b. Do college students delivered text in a single combined form outperform students delivered two separate texts on comprehension measures?
   c. Is there an interaction between task instructions and text type on comprehension measures?

3) Effects of Task Instructions and Text Type on Multiple-text Integration
   a. Do college students delivered task instructions to know and understand the task of integration outperform students delivered task instructions to integrate and students delivered task instructions to comprehend on integration measures?
   b. Do college students delivered text in a single combined form outperform students delivered two separate texts on integration measures?
   c. Is there an interaction between task instructions and text type on integration measures?

4) Relationship between Need for Cognition, Relational Reasoning and Integration
   a. Does Need for Cognition and/or the Test of Relational Reasoning predict integration?
   b. Does Need for Cognition and/or the Test of Relational Reasoning moderate the effect of task instructions on integration?

Method

Participants.

Participants were 577 students (387 female) recruited during the fall 2012 semester from one large lecture section of an introductory physiology course. While the course was a different course than Experiment 1, it was still a large introductory biology lecture course for students in life sciences majors. A total of 585 participants attended an experimental research session, but data was lost from eight students when computers or browsers malfunctioned part-way through the experiment. Although the malfunction was corrected, participants were re-assigned to a different condition. These participants were removed from all analyses.

Participants ranged in age from 18 to 35, with the majority of participants being 18 (34.1%), 19 (33.6%), 20 (17.3%), or 21 (9.2%); few participants were 22 and over (5.7%). The majority of participants identified as White (80.2%), with the remaining participants primarily identifying as American Indian (0.5%), Asian (6.1%), Black
(5.7%), and Hispanic (3.8%). Several participants indicated “other” (3.3%) or did not respond (0.3%). Participants represented a range of semester standing; freshman (0 – 1 completed semesters; 40.8%), sophomore (2 – 3 completed semesters; 32.6%), junior (4 – 5 completed semesters; 15.4%), senior (6 – 7 completed semesters; 8.3%), and greater (8 – 16 completed semesters; 2.8%). Self-reported grade point average (GPA) ranged from 2.0 to 4.85 with the mean GPA of 3.48 (SD = 0.49). Of the 547 participants who reported a valid Verbal SAT score, the mean was 597.6 (SD = 78.8). Most participants reported English as their first language (93.4%). Less than half of the participants reported being in a biology-related major (39.3%), while the remaining reported a not biology-related major. All participants implied consent. [See Appendix B for a copy of the Implied Consent document.]

**Design.**

Participants were randomly assigned to one of six conditions in a 2 x 3 design with independent variables: Text Type (separate texts vs. combined text) x Task Instructions (read to comprehend (RTC) vs. read to integrate (RTI) vs. read to integrate plus understanding integration (RTI+U)). Three individual difference measures assessed biology prior knowledge, Need for Cognition, and relational reasoning. Two dependent measures assessed single-text comprehension: the SVT measures assessed small-grain comprehension and the PIT measures assessed large-grain comprehension. Three dependent measures assessed integration: the IVT measured small-grain integration, and both verbal free recall integration (vFRI) and drawing free recall integration (dFRI) measures assessed large-grain integration.

**Materials.**

**Individual difference measures.**

**Demographics.** The demographic questions were unchanged from Experiment 1, except for the inclusion of two new questions regarding verbal SAT score and language.

**Biology prior knowledge.** The 10-item biology prior knowledge measure was unchanged from Experiment 1, \( \alpha = .342 \).
Need for Cognition. As in Experiment 1, the short version of the Need for Cognition (NFC) Scale was administered (Cacioppo et al., 1984). The scale and instructions used in Experiment 1 were consistent with Cacioppo and colleagues (1984). Cacioppo, Petty, Feinstein and Jarvis (1996) reported that variations of scale and anchor in empirical implementations resulted in minimal effect on the results. The revised version used in Experiment 2—with simplified instructions, expanded 9-point scale, and revised anchors—is comparable with others’ use in the literature (cf., Tanaka, Panter, & Winborne, 1988). While students responded to the same 18 statements, the scale was expanded from 5 points to 9 points and the instructions and anchor options were shortened and simplified. Participants were told to “Indicate your degree of agreement or disagreement with each of the statements below.” Like Experiment 1, participants moved a slider, but the scale was expanded to -4, representing “very strong disagreement”, and +4, representing “very strong agreement”. Participants’ responses were calculated by summing the ratings of all 18 statements after reverse coding the nine items. Possible scores could range from -72 to +72, \( \alpha = .884 \). [See Appendix B for a sample of the revised version of the Need for Cognition measure.]

Test of Relational Reasoning. The Test of Relational Reasoning (TORR; Alexander, Dumas, Fox, & Firetto, in prep) was added to Experiment 2 as an additional individual difference variable. The TORR was a 32 item multiple-choice measure that contained four subscales (i.e., analogy, anomaly, antithesis, and antinomy). Each subscale was composed of eight four-choice items. Each item required the interpretation of the relationships between diagrams. For each set the type of relational reasoning required varied so that sets assessed the ability to reason by analogy, anomaly, antithesis, and antinomy separately. Each set provided instructions, with two corresponding example items. One item appeared on each page, and the order of sets was randomized. The order of items within a set was the same for all participants. Each item had one correct answer, and the possible range of scores was between 0 and 32, \( \alpha = .776 \). [See Appendix B for two sample items from the TORR measure.]

Knowledge Measures.

Task instructions verification. The task instructions verification measure was the same as that used in Experiment 1. In this measure, participants were given a large, open-ended textbox and asked to “repeat the instructions you were just given and describe them with as much detail as possible” immediately after being presented with either RTC or RTI instructions. The author and an educational psychology graduate student each
coded 50% of the responses using the same rubric from Experiment 1. Inter-rater agreement was calculated on 20% of the responses and was 98%.

**Single-text comprehension.**

**Small-grain text comprehension: Sentence verification technique.** The actual items used on the SVT comprehension measure were not changed from Experiment 1. The instructions and question prompt were changed in an effort to improve the reliability of scores. Specifically, Experiment 1 participants may have performed poorly on this measure because of uncertainty regarding how to respond to text paraphrases. For Experiment 2, more detailed instructions and an example were added. Figure 3.4 provides a visual of the instructions with the new example. For participants in the separate texts condition, the instructions were provided at the beginning of each SVT measure. In addition to the changes in instructions, the question prompt used to elicit responses was also changed. Participants were asked, “Does this sentence have the same meaning as a sentence from the text?” and responded by selecting “same meaning” or “different meaning” rather than “yes” or “no”. This modification was done in an effort to clarify students’ understanding of the task.

![Figure 3.4 Sentence verification technique instructions with example as seen by a participant in the separate texts condition.](image)

Participants in the combined text condition received a combined SVT with all 32 items. Items were presented in sets of eight, randomized within the set: the first set of eight items from endocrine system, the first set of eight items from the urinary system, the second set of eight items from the endocrine system, and finally the
second set of eight items from the urinary system. This presentation was consistent with the order of systems presented in the text. All SVT instructions were parallel to those administered in the single text condition.

Participants received one point for each correct SVT response. A correct response was given when a participant indicated “Same Meaning” for sentences that were either original or paraphrased and “Different Meaning” for sentences that were either meaning change or distractor. The possible range for each test was between 0 and 16 for each system. The SVT measure assessed small-grain comprehension for each text, endocrine\(^1\), \(\alpha = .286\); urinary\(^1\), \(\alpha = .400\).

Large-grain text comprehension: Principle identification technique. Revisions were made to the two, four-item Principle Identification Technique (PIT) large grain comprehension measures that were used in Experiment 1. First, several of the scenarios were altered to improve the quality of the item. Item analysis of the eight scenarios used in Experiment 1 revealed several with poor item statistics. In several cases, scenarios written to have a different deep structure were judged as similar, by the majority of participants (and vice versa). Two biology undergraduate teaching assistants acted as consultants and examined each item. Both consultants independently indicated concern for the items with poor discrimination and difficulty statistics. They provided explanations for the concern. For example, the similar surface structure \(\times\) different deep structure scenario in from the urinary system was:

On Francine’s 30th birthday she noticed a “floater” in her vision. Confused as to why she was seeing them for the first time, she went to the eye doctor concerned. Her eye doctor assured her she was fine, but checked to be sure the retina was not detached. After ensuring her retina had not detached from the tissue, he began to describe the jelly-like fluid in the eyes called vitreous. He told her that as she grows older the fluid thickens causing small particles in her eye to become more visible. The small spots and “floaters” that she sees are harmless and would likely not cause any future vision problems.

Both biology consultants expressed that students might consider the “fluid in the eyes” as something that the might be related to filtration. In particular, this was because of the wording “small particles”. Despite that the kidney and urinary system have no relation to this, these similar wording may have inadvertently caused confusion. This item was removed, and a new scenario was developed for Experiment 2. Furthermore, one endocrine system PIT scenario and two urinary system PIT scenarios were thoroughly revised. Minor word changes were made to clarify other scenarios.

Other revisions to the PIT measure included changes to the instructions and scale. The scale was changed from the dichotomous “yes” or “no”, to a degree of similarity. Participants responding to the urinary system PIT measure scenarios were prompted to “compare this scenario to the urinary system” and drag the slider along a bar from 0 (“very different”), to 10 (“very similar”). Starting position of the bar was centered, and once participants
moved the bar, a number that corresponded to its position was visible on the right. For each measure, all four scenarios were presented on the same page in random order, so participants would have a frame of reference. This response scale is consistent with the Wiley and Voss’ (1999) use of the PIT, and it is likely to be more sensitive to participants’ perception of varying degrees of similarity.

Participants received endocrine and urinary PIT measures in the same order that the texts were presented. Participants who received the combined text received the urinary system PIT measure prior to the endocrine system measure. See Figure 3.5 below for a visual of the revised instructions with the provided example.

![Figure 3.5 Principle identification technique instructions for endocrine system measure with example.](image)

Scenarios with a different deep structure were reverse coded, and the average of the four scenarios was calculated. The maximum score range was between 0 and 10 for the measure corresponding to a single text topic. The PIT measures assessed large-grain comprehension for each system. Although the reliability of scores was improved from Experiment 1, internal consistency was still rather low, endocrine system, $\alpha = .262$; urinary system, $\alpha = .201$. [See Appendix B for the revised PIT measures.]

**Multiple-text integration**

*Small-grain integration: Inference verification technique.* Revisions to the IVT measure included changes to the instructions, response format, and item re-writes. Reliability calculation and item analysis of the responses from Experiment 1 indicated a need to revise items. The new 16-item IVT measure was developed in a manner similar to the SVT measure. The author started with the initial 10 true inferences and constructed two additional
versions of each one: a paraphrase and a meaning change. Like the SVT paraphrase items, the paraphrase items were modified from true inferences to change the specific wording, while maintaining the same true inference. The meaning change versions of the items were modified to reverse the meaning of the inference, thus making the inference false. See Table 3.9 for examples of an original true inference and the constructed alternate versions.

Table 3.9

<table>
<thead>
<tr>
<th>Version</th>
<th>Inference Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>When antidiuretic hormone (ADH) is secreted by the hypothalamus more water will enter the vasa recta and peritubular capillaries.*</td>
</tr>
<tr>
<td>Paraphrase</td>
<td>As the hypothalamus secrets antidiuretic hormone (ADH) a larger amount of water will enter the vasa recta and peritubular capillaries.</td>
</tr>
<tr>
<td>Meaning Change</td>
<td>When antidiuretic hormone (ADH) is secreted by the hypothalamus less water will enter the vasa recta and peritubular capillaries.</td>
</tr>
</tbody>
</table>

Note: Underline emphasis added here for clarity. *Indicates item used in measure.

The new version of the IVT measure contained four randomly selected versions of each original, paraphrase, and meaning change statements. It is important to note that in two instances, two versions of the same inference were used. This repetition was used because there the measure from Experiment 1 contained only 10 true inferences, and the author did not want to reduce the number of items below 16. For both repetitions, one true (i.e., original or paraphrase) and one false (i.e., meaning change) version were selected. Four distractor items were also selected. These were revised from the most psychometrically sound distractor items from Experiment 1. The new version of the IVT measure was reviewed by four educational psychology graduate student consultants and the two undergraduate biology teaching assistants to confirm accuracy and clarity.

The instructions added a clearer explanation of the task and provided an example. See Figure 3.6 below for a visual of the instructions with the provided example. Additionally, instead of selecting “yes” or “no” in response to “can this statement be reasonably inferred”, participants selected “true” or “false”. These changes were made to facilitate students’ understanding of the task, and reduce confusion. Items appeared one per page in randomized order.
Figure 3.6 Inference verification technique instructions with example.

Responses to original or paraphrase inferences with “true” and meaning change or distractor inferences with “false” were considered correct. Each correct response received one point. The possible range of scores was between 0 and 16. The IVT measure assessed participants’ small-grain integration of two systems. The above revisions to increase internal consistency of the measure were not successful, $\alpha = .168$. It is possible that because the items are true/false, participants’ guessing may be a contributing factor to the poor reliability of the scores. [See Appendix B for the revised IVT measure.]

**Large-grain integration: Verbal and diagram free recall integration**

**Verbal free recall integration (vFRI).** After reading the experimental text(s), participants were instructed to write all that could be remembered. They were asked to, “Please use the space below to type what you remember from the texts. Please spend at least five minutes on this question.” Participants in the combined text condition received instructions that referred to “the text” in a singular form. At the bottom of the page was a timer that showed how long, in minutes and seconds, the participants spent on the page. Participants were not required to wait the full five minutes before proceeding, but time was recorded.
The vFRI measure allowed for an assessment of integration without contaminating the other measures. Specifically, this measure was selected because of the capacity to score the responses in order to obtain a measure of participants’ ability to generate broad connections (i.e., integration) between the two systems. Where the IVT measure assessed whether participants are able to recognize a finite number of specified inferences between the texts, the vFRI was sensitive to participants’ generation of broad connections between the systems. Furthermore, the vFRI was advantageous because it measured unprompted, spontaneous, integration of concepts.

The author, in collaboration with an educational psychology graduate student, developed a four-point rubric for coding the large-grain integration of concepts from participants’ verbal free recalls. Descriptively, the responses (a) clearly integrated between systems, (b) clearly separated the two systems from each other, (c) neither connected nor separated the two systems, or (d) responded with a blank or incomprehensible response. After inter-rater agreement was established, two raters each coded half of the responses. Inter-rater agreement was established on 20% of the participants’ responses; the two raters achieved 86% agreement. [See Appendix B for the vFRI rubric and examples of responses from participants.]

**Drawing free recall integration (dFRI).** After reading the experimental text(s) and responding to the vFRI, participants were instructed to draw all that could be remembered. They were given a blank sheet of white paper and asked to, “use the blank space to draw what you remember from the texts. Please spend at least five minutes on this question. When you are finished, turn the paper over so the blank side faces up.” Participants in the combined text condition received instructions that referred to “the text” in a singular form. At the bottom of the website was a timer that showed how long, in minutes and seconds, the participant spent on the page. Participants were not required to wait the full five minutes before proceeding, but time was recorded.

Like the vFRI, the dFRI allowed for an additional measure of integration without contaminating the other measures. The free recall method of collecting a measure of participants’ ability to generate broad connections between the two systems was applied to assess participants’ generation of connections in the diagrams. Again, the dFRI is advantageous because it measures the unprompted, spontaneous, integration of concepts.

The author, in collaboration with two educational psychology graduate students, developed a four-point rubric for coding the large-grain integration of concepts from participants’ diagram free recall responses. Descriptively, the responses, (a) clearly integrated between systems, (b) clearly separated the two systems from each other, (c) neither connected nor separated the two systems, or (d) responded with a blank or other incomprehensible
response. After inter-rater agreement was established, two raters each coded half of the responses. Inter-rater agreement was established on 20% of the participants’ responses; the two raters achieved 96% agreement. [See Appendix B for the dFRI rubric and examples of responses from participants.]

**Open-ended comments (optional).**

An optional open-ended comment box was included to allow participants to respond with any comments or concerns they had regarding the study. This prompt was the same as the prompt delivered in Experiment 1, and was included to provide descriptive information about technical or other problems.

**Independent variable.**

**Experimental text(s).**

As in Experiment 1, participants read about two different biological systems: the endocrine system and the urinary system. Half of the participants received the information presented in the same format as Experiment 1 (i.e., two separate texts). For participants assigned to the two separate texts condition, there were no changes from Experiment 1 and text order was counter balanced. The other half of the participants received the same content in the form of a single combined text. The single combined text was 3,513 words in length, had a Flesch Reading Ease of 40.8, and a Flesch-Kincaid Grade Level of 12.5; it was supplemented with all 12 visual representations. This combined text was created by merging chunks of the two separate texts into a single combined text. Because both texts had the same three main sections (i.e., introduction to the system, glands/organs of the system, and how the system functions), for each section, the single text combined content from both systems. This combined version of the text kept whole sections intact so that the single and combined texts present content consistently. The format of the combined text was: introduction of the urinary system, introduction of the endocrine system, the organs of the urinary system, the glands of the endocrine system, how the urinary system functions, and how the endocrine system functions. The only wording changes involved revisions to section headings to clarify content transitions. Qualtrics recorded the time spent on each text page. [See Appendix B for the combined text.]
Task instructions.

Participants were delivered instructions corresponding to the randomly assigned condition. Instructions for both RTC and RTI conditions were identical to those given in Experiment 1. Because half of the participants read a single combined text, however, the instructions delivered to those participants were modified to refer to the texts in a singular form (e.g., “read two biology texts” was modified to “read a biology text”). The revised instructions given to the participants in the RTC condition also assigned to read the single combined text were:

INSTRUCTIONS: READ CAREFULLY
You will be asked to read a biology text, read it as if you were studying for a test in your course. The text has a number of biology concepts that are covered. While you are reading the text, try to study the concepts and comprehend it to the best of your ability.

Research has shown that if you read the text carefully you may be able to learn more than if you didn’t.

Participants assigned RTI condition and assigned to read a single combined text were provided the following instructions:

INSTRUCTIONS: READ CAREFULLY
You will be asked to read a biology text, read it as if you were studying for a test in your course. Within the text there are a number of biology concepts that can be related to each other. While you are reading the text, try to study how the concepts are connected to other concepts.

Research has shown that if you can combine the information within the text while you are reading, you may be able to learn more than if you didn’t.

A third instructions condition was added in this study. In this read to integrate +understand (RTI+U) condition, participants received instructions consistent with the RTI condition, but after responding to the task instructions verifications measure, these participants then received additional instructions to ensure that participants understood the instructions to integrate. Adding this condition allows the comparison between college students who are simply directed to integrate texts (RTI) to a condition where these instructions are enhanced by supporting participants’ understanding of what it means to integrate texts (RTI+U).

The +understanding support consisted of two open-ended questions. After responding to the task instructions verification item, participants were reminded of the instructions and then stimulated to reflect on the task by describing them in their own words. Then, participants were asked to practice the task on two example excerpts. Participants were not given a correct answer. See Figure 3.7 for the +understanding support.
Since the purpose of reading the two biology texts is to study how the concepts in one text are connected to the concepts in the other, it is important that you understand what this means.

Use the text box below to describe in your own words what it means to combine information in two texts.

Please read the two example excerpts, and type below how you would combine the information.

<table>
<thead>
<tr>
<th>Example Excerpt 1</th>
<th>Example Excerpt 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some dogs have a &quot;double coat&quot; that is made up of two parts, a soft undercoat that keeps them warm, and a coarse top coat that repels water.</td>
<td>In the spring, many pet owners bring their dog to the groomer to brush out the undercoat and trim the top coat to avoid excessive shedding.</td>
</tr>
</tbody>
</table>

Figure 3.7 Two questions provided to participants for the +understanding support for participants in the RTI+U condition.

All participants provided a response to both questions (i.e., no participants left the text box blank, reported “I don’t know” or other vague non-answer), even though responses varied with respect to the accuracy or degree of integration. Responses were not scored for accuracy. Several examples to the practice question are provided in Table 3.10 below. Qualtrics recorded the time spent on the page that delivered the +understand remind and practice tasks.
Table 3.10

Examples of participants’ responses to the understand practice task

<table>
<thead>
<tr>
<th>Participants unedited responses to the understanding practice question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because dogs have two different coats that are meant for different times of the year it would make sense to take them to a pet groomer in the spring to help clear out the useless coat that is meant to keep the dog warm. [sic]</td>
</tr>
<tr>
<td>Dogs have a soft coat underneath their skin and a coarse coat on top that repels water. In the summer, owners must brush their dogs undercoat and trim the top coat to avoid shedding. [sic]</td>
</tr>
<tr>
<td>Dogs have two different coats to keep them warm and to help repel water. When the weather changes, one of the coats may not be needed so the dogs sheds a coat. To prevent shedding, groomers can remove a coat instead. [sic]</td>
</tr>
<tr>
<td>Since some dogs have a &quot;double coat&quot; and the coat under their top coat keeps them warm, the groomer should be careful while he is cutting the top coat in order to not cut the soft, undercoat. [sic]</td>
</tr>
<tr>
<td>Pet owners do not trim their pets in the winter because the dogs two coats keep them warm during the cold months, however they do trim their dog's hair in the spring to keep them cool and avoid the extreme release of dog hair. [sic]</td>
</tr>
<tr>
<td>I would combine this excerpts by the common factor that exists in both, the mentioning of an undercoat. [sic]</td>
</tr>
</tbody>
</table>

**Procedures.**

During recruitment, students were informed that participation in the study would entail reading biology text and answering questions about what they read. They were also notified that the study would be delivered as two parts. Part 1 would be done in person at a session during the following week, and Part 2 would be available online for a period of two weeks following the completion of Part 1. Participants received six points of extra credit for completing Part 1 and four points of extra credit for completing Part 2. Participation in Part 1 was required to be eligible for Part 2. Students were told that it would take approximately 120 minutes to complete Part 1, and Part 2 was estimated to take approximately 45 minutes. Students who wished to participate in Part 1 were given a website link to reserve a spot in one of 15 sessions. Part 1 contained all of the same measures as Experiment 1, as well as the added vFRI and dFRI measures; Part 2 only contained the new TORR individual difference measure. For Part 1, participants showed up at the time and location of the session that they reserved via the website. Sessions were offered at various times over the course of six academic days and were located at various computer labs throughout campus reserved for the study. Sessions were reserved for two-hour slots, and all participants started at the same time for each session. Computer labs varied in size, and ranged from 35 to 75 computers per lab. The author administrated all 15 sessions. Upon the start of the session, the author handed a blank sheet of paper to all
participants and reviewed the instructions using a PowerPoint slide to ensure all sessions were delivered equivalent verbal instructions regarding study procedures. The full version of the script and PowerPoint slide are available in Appendix B. After the verbal script was delivered, participants were instructed to log on to their computers, open Firefox browser, and visit the link to the Qualtrics survey to begin. The author walked around the room, and stood in various locations throughout the entire duration of the session. Students who needed help or had questions quietly raised their hands and were helped on an as-needed basis.

After completing the implied informed consent, Qualtrics randomly assigned participants to one of six conditions (Task Instructions x Text Type). Upon first opening the survey, participants were instructed to “Please read all instructions very carefully!” Students completed instruments in the following order (See Table 3.11).

Table 3.11

Order of procedures for each of the six conditions for Part 1 in Experiment 2

<table>
<thead>
<tr>
<th></th>
<th>RTC x Separate Texts</th>
<th>RTC x Combined Text</th>
<th>RTI x Separate Texts</th>
<th>RTI x Combined Text</th>
<th>RTI-U x Separate Texts</th>
<th>RTI-U x Combined Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Demographics</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Biology Prior Knowledge</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>NFC</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Task Instructions</td>
<td>Comprehend Separate Texts</td>
<td>Comprehend Combined Text</td>
<td>Integrate Separate Texts</td>
<td>Integrate Combined Text</td>
<td>Integrate Separate Texts</td>
<td>Integrate Combined Text</td>
</tr>
<tr>
<td>Task Instruction Verification</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Understand Task</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Counterbalanced Endocrine &amp; Urinary</td>
<td>Counterbalanced Endocrine &amp; Urinary</td>
</tr>
<tr>
<td>Text Type</td>
<td>Counterbalanced Endocrine &amp; Urinary</td>
<td>Combined Endocrine &amp; Urinary</td>
<td>Counterbalanced Endocrine &amp; Urinary</td>
<td>Combined Endocrine &amp; Urinary</td>
<td>Counterbalanced Endocrine &amp; Urinary</td>
<td>Combined Endocrine &amp; Urinary</td>
</tr>
<tr>
<td>vFRI</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>dFRI</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>SVT</td>
<td>Full Endocrine &amp; Full Urinary</td>
<td>Full Endocrine &amp; Full Urinary</td>
<td>Full Endocrine &amp; Full Urinary</td>
<td>Full Endocrine &amp; Full Urinary</td>
<td>Full Endocrine &amp; Full Urinary</td>
<td>Combined Endocrine &amp; Urinary</td>
</tr>
<tr>
<td>IVT</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>PIT</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Open-ended Response</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

Note: “Check mark” indicates that participants in that condition received that measure, and N/A indicates that the measure was not applicable to that condition.
All participants from Part 1 were e-mailed a link to Part 2. They were told that Part 2 was unrelated to biology content and considerably different from Part 1. Participants were able to visit the link at a time and location of their choosing, and Part 2 was delivered via Qualtrics. Once participants clicked on the link, they were reminded (1) to find a quiet place to take the survey, and eliminate distractions such as music, television, and close all other websites; (2) to not discuss the survey until all students have completed it; (3) to remain focused and put forth good effort in answering the questions. All participants, regardless of condition were given the TORR measure, followed by the open-ended comment again.

Results

Preliminary analysis.

Descriptive statistics are presented in Table 3.12. For clarity, measures are divided into demographic information, individual difference measures, and dependent measures and are presented for each of the six conditions.
Table 3.12

Descriptive statistics for demographics, individual differences, and dependent measures

<table>
<thead>
<tr>
<th></th>
<th>Read to Comprehend</th>
<th>Read to Integrate</th>
<th>Read to Integrate + Understand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Combined Text</td>
<td>Separate Texts</td>
<td>Combined Text</td>
</tr>
<tr>
<td></td>
<td>(n = 95)</td>
<td>(n = 97)</td>
<td>(n = 99)</td>
</tr>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>19.31 (1.28)</td>
<td>19.10 (1.13)</td>
<td>19.59 (2.37)</td>
</tr>
<tr>
<td>Sex (#males)</td>
<td>n = 34</td>
<td>n = 26</td>
<td>n = 37</td>
</tr>
<tr>
<td>GPA</td>
<td>3.45 (0.44)</td>
<td>3.43 (0.57)</td>
<td>3.49 (0.51)</td>
</tr>
<tr>
<td><strong>Individual difference measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPK</td>
<td>5.32 (1.79)</td>
<td>5.23 (1.67)</td>
<td>5.00 (1.82)</td>
</tr>
<tr>
<td>TORR</td>
<td>16.96 (5.97)</td>
<td>15.99 (4.80)</td>
<td>16.45 (5.24)</td>
</tr>
<tr>
<td><strong>Dependent measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVT End.</td>
<td>9.82 (2.36)</td>
<td>9.88 (2.18)</td>
<td>9.99 (2.27)</td>
</tr>
<tr>
<td>SVT Uri.</td>
<td>10.82 (2.44)</td>
<td>10.64 (2.09)</td>
<td>10.56 (2.15)</td>
</tr>
<tr>
<td>PIT End.</td>
<td>5.91 (5.39)</td>
<td>5.38 (4.82)</td>
<td>5.04 (4.62)</td>
</tr>
<tr>
<td>PIT Uri.</td>
<td>8.50 (5.29)</td>
<td>8.16 (5.43)</td>
<td>6.58 (5.26)</td>
</tr>
<tr>
<td>IVT</td>
<td>9.54 (2.03)</td>
<td>9.06 (2.08)</td>
<td>9.08 (2.06)</td>
</tr>
<tr>
<td>vFRI</td>
<td>1.78 (0.75)</td>
<td>1.36 (0.72)</td>
<td>1.79 (0.78)</td>
</tr>
<tr>
<td>dFRI</td>
<td>1.74 (0.56)</td>
<td>1.73 (0.58)</td>
<td>1.69 (0.62)</td>
</tr>
</tbody>
</table>
Skewness and kurtosis statistics were assessed. The vFRI was positively skewed, while the dFRI and TORR were negatively skewed. The urinary system SVT and PIT measures were also negatively skewed. The NFC measure was leptokurtic, while the drawing recall measure and the urinary PIT measures were platykurtic. All other measures were approximately normal, except for the two PIT measures, which were strongly negatively skewed.

Time. Qualtrics recorded time on the page that delivered the task instructions as well as each page presenting the texts. For each of these, time ranges varied widely and the distributions were positively skewed. Time spent on the page delivering the task instructions ranged from 1.4 seconds to 39.5 seconds. Statistical outliers were removed using the outlier labeling rule with $g = 2.2$ (Hoaglin & Iglewicz, 1987). These outliers were removed only in the figures and means presented as part of the time analysis presented here. These outliers were removed because the purpose of this analysis was to determine if participants spent a reasonable amount of time on the instructional activities, and if the times between conditions were comparable across conditions. Including the outliers distorted the means and histograms. Figure 3.8 contains histograms, which show these time distributions on the instructions by condition; Figure 3.9 shows the time spent on each of the texts read separately; Figure 3.10 shows the time spent on the combined text. Table 3.13 presents the time spent for each condition on the task instructions as well as the respective text(s).

![Histogram of time spent on instructional task by condition](image)

*Figure 3.8. Time spent on the delivery of the task instructions for both RTC and RTI. *Seven statistical outliers not presented in the graph.*
Figure 3.9. Time spent on the pages delivering the endocrine text and the urinary text. *Four statistical outliers not presented in the graph.

Figure 3.10 Time spent on the page delivering the single combined text. *One statistical outlier not presented in the graph.

After removal of the outliers, the mean time spent on the page containing the task instructions was 13.0 seconds (SD = 6.2) for the RTC condition and 14.8 seconds (SD = 7.5) for the RTI conditions. Participants spent an average of 8.5 minutes (SD = 237.1 seconds) reading the endocrine text (1780 words), an average of 7.8 minutes (SD = 211.6 seconds) reading the urinary text (1702 words), and an average of 16.8 minutes (SD = 457.4 seconds) reading the combined text. With the change in location, the distributions when compared to Experiment 1 are less skewed, and the time spent on all of the measures was much longer in Experiment 2.

With the change in location, the distributions were less skewed than Experiment 1. Overall the time spent on all of the measures was longer in Experiment 2.
**Condition effect on the recall of task instructions.**

Participants were delivered task instructions corresponding to their assigned condition. After being delivered the task instructions, participants were asked to report what they remembered by re-typing them into a textbox. The responses were coded as to whether they had recognized the main point of the task instructions (i.e., “reading” or “comprehending the texts” for the RTC participants; “integrating” or “connecting the texts” for the RTI and RTI+U participants). Eighty-one participants who read RTI instructions (from either the RTI or RTI+U conditions) reported generic responses regarding reading. These participants were not able to verify the purpose of integration, and thus, were categorized as not being able to verify the task instructions. As a whole, 74% of the participants were able to report knowledge of the task; 88% of the RTC condition and 67% of the RTI and RTI+U conditions. While the percentage of participants successful at recalling the task instructions increased from Experiment 1, there is still a surprisingly large portion of participants who were unable to verify the task instructions immediately after delivery. Table 3.13 provides a breakdown of participants for task instruction and correct verification.

Table 3.13

<table>
<thead>
<tr>
<th>Task Instructions</th>
<th>RTC</th>
<th>RTI &amp; RTI+U</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification</td>
<td>Yes</td>
<td>169</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>23</td>
<td>126</td>
</tr>
<tr>
<td>Total</td>
<td>192</td>
<td>385</td>
<td>577</td>
</tr>
</tbody>
</table>

*Note: RTI and RTI+U are combined because both conditions were delivered the same RTI task instructions*

A Chi Square test measured the association between participants’ correct verification of task instructions and the actual instructions that were delivered. A significant association was found, $\chi^2(1, 577 = 318) = 28.792, p < .001$. Participants who were delivered RTC instructions were more likely to report knowledge of the delivered task instructions than participants who were delivered the RTI task instructions.

One explanation for being unable to verify the task instructions is that some students may have skipped past the page delivering the task instructions. This explanation is supported by the time data reported earlier. In Experiment 2, this appears to be less common than in Experiment 1, but it is still of concern. Due to the design of the experiment, participants in the RTC and RTI conditions were unable to go back to the page with the instructions.
Even though all participants were delivered instructions, many never received them. Thus, differences on the posttest measures would not be expected for participants who never received the task instructions. To test for this, Experiment 2 included a +understanding condition. After completing the task instruction verification, participants in the RTI+U condition received a reminder of the task along with two questions developed to ensure participants both received and understood the RTI task.

**Effect of task instructions on comprehension.**

**Small-grain comprehension.**

A MANCOVA, with the two SVT scores as the dependent variable and biology prior knowledge as the covariate assessed the impact of task instruction and text type. All assumptions were assessed and met. The correlation between biology prior knowledge and both SVT measures was significant, \( r = .207 \) (endocrine) and \( r = .115 \) (urinary), permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and no significant interactions were found. Levine’s homogeneity of variance was not significant, \( p = .661 \) (endocrine) and \( p = .899 \) (urinary), suggesting the variances for both dependent variables were equal. Box’s M was not significant, \( p = .675 \), indicating the covariance matrices of the dependent variable are equal across groups, and as a result, Wilkes’ \( \lambda \) was interpreted.

There was not a significant interaction between task instruction and text type, Wilkes’ \( \lambda \), \( F(2, 1138) = 0.913, p = .237, \eta^2 = .001 \), indicating that the effects of task instruction were consistent across both text types on comprehension. There was not a significant effect for either task instruction, \( F(2, 1138) = .865, p = .484, \eta^2 = .003 \), indicating that participants who were given RTC task instructions did not score significantly higher than participants given RTI task instructions or RTI+U task instructions on small-grain comprehension measures, or text type, \( F(2, 569) = .221, p = .802, \eta^2 = .001 \), demonstrating that there was not a significant difference between participants who read either two separate texts or a single combined text on comprehension. This finding suggests that the task of directing college student readers’ attention to comprehension does not result in higher small-grain
comprehension scores, nor does the task of directing college student readers’ attention to integration harm small-grain comprehension relative to participants who were instructed to focus on comprehension.

**Large-grain comprehension.**

A MANCOVA, with the two PIT scores as dependent variables and biology prior knowledge as the covariate assessed the impact of task instruction and text type. All assumptions were assessed and met. The correlation between biology prior knowledge and both SVT measures was significant, $r = .150$ (endocrine) and $r = .180$ (urinary), permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and no significant interactions were found. Levine’s homogeneity of variance was not significant, $p = .542$ (endocrine) and $p = .525$ (urinary), suggesting the variances for both dependent variables were equal. Box’s M was not significant, $p = .369$, indicating the covariance matrices of the dependent variable are equal across groups, and as a result, Wilkes’ $\lambda$ was interpreted.

There was not a significant interaction between task instruction and text type, $F(2, 1138) = 1.466, p = .210, \eta^2 = .005$, indicating that the effects of task instruction were consistent across both text types on comprehension. There was not a significant effect of either task instructions, $F(2, 1138) = 1.219, p = .301, \eta^2 = .004$, indicating that participants who were given RTC task instructions did not score significantly higher than participants given RTI task instructions or RTI+U task instructions on large-grain comprehension measures, or text type, $F(2, 569) = 0.868, p = .421, \eta^2 = .003$, demonstrating that there was not a significant difference between participants who read either two separate texts or a single combined text on comprehension. This finding, like the finding for small-grain comprehension, suggests that the task of directing college student readers’ attention to comprehension does not result in higher large-grain comprehension scores, nor does the task of directing college student readers’ attention to integration harm large-grain comprehension relative to participants who were instructed to focus on comprehension.
Effects of task instructions on integration.

Small-Grain Integration.

An ANCOVA, with biology prior knowledge as the covariate, assessed the impact of the task instructions and text type on the IVT measure of small-grain integration. All assumptions were assessed and met. The correlation between biology prior knowledge and the IVT measure was significant, \( r = .126 \), permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and no significant interaction was found. Levine’s homogeneity of variance was not significant, \( p = .977 \), indicating equality of variances for the IVT variable.

There was not a significant interaction between task instruction and text type, \( F(2, 576) = 2.216, p = .110, \eta^2 = .008 \), indicating that the effect of the task instruction was consistent across both forms of text type. There was not a significant effect of task instruction, \( F(1, 576) = 0.614, p = .860, \eta^2 = .001 \), indicating that there was not a significant difference between participants given RTC instruction, RTI instruction, or RTI+U instruction on the IVT measure. There was not a significant effect of text type, \( F(1, 576) = 0.021, p = .886, \eta^2 = .000 \), indicating that there was not a significant difference between participants who read either a single combined or two separate texts on the IVT measure. This finding suggests that neither directing college student readers’ attention to the relationship between content nor providing a combined version of the texts is sufficient to impact readers’ integration of the content on an IVT measure of small-grain integration.

In order to fully test the hypothesis that students who could verify the task instruction would have higher scores of small-grain integration, a follow-up analysis was conducted. For both the RTC and RTI conditions, participants who did not report knowledge of the respective task instructions were removed. No participants were removed from the RTI+U condition, because all participants in this condition completed understanding questions after the verification task was completed. This resulted in 169 remaining participants in the RTC condition and 124 remaining participants in the RTI condition, and 190 in the RTI+U condition. The resulting means and standard deviations for IVT scores are shown in Table 3.14.
Table 3.14

Means and standard deviations for the IVT scores for the subset of participants who reported knowledge of the task instructions

<table>
<thead>
<tr>
<th></th>
<th>RTC Combined Text (n=80)</th>
<th>RTC Separate Texts (n=89)</th>
<th>RTI Combined Text (n=58)</th>
<th>RTI Separate Texts (n=66)</th>
<th>RTI+U Combined Text (n=95)</th>
<th>RTI+U Separate Texts (n=95)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVT</td>
<td>9.59 (2.12)</td>
<td>9.09 (2.08)</td>
<td>9.48 (2.02)</td>
<td>9.32 (2.02)</td>
<td>9.02 (1.96)</td>
<td>9.40 (2.04)</td>
</tr>
</tbody>
</table>

A 2 x 2 ANCOVA tested the effect of task instructions and text order on the IVT measure of integration. All assumptions were again assessed and met. The correlation between biology prior knowledge and the IVT measure was significant, \( r = .104 \), permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and no significant interactions were found. Levine’s homogeneity of variance was not significant, \( p = .922 \), indicating equality of variances for the IVT variable. As with the full sample of participants, there was not an interaction of task instructions and text type, \( F(2, 476) = 2.037, p = .132, \eta^2 = .008 \), nor a significant effect of task instructions on the IVT measure, \( F(2, 476) = 0.327, p = .721, \eta^2 = .001 \). Finally, there was no significant effect of text type, \( F(1, 476) = .309, p = .579, \eta^2 = .001 \). This further confirms the assertion that awareness and/or understanding that one should integrate is not sufficient to increase small-grain integration.

**Large-grain integration.**

A new contribution to Experiment 2 is the addition of large-grain measures of integration: verbal free recall integration (vFRI) and drawing free recall integration (dFRI). A MANOVA tested the impact of the task instruction and text type on the two measures of large-grain integration. All assumptions were assessed and met. The use of the biology prior knowledge was not used as a covariate, because it did not meet the requirements.

There was not a significant interaction between task instruction and text type, \( F(4, 1156) = 1.040, p = .385, \eta^2 = .004 \), indicating that the effects of the task instruction were consistent across both text types. There was not a significant effect of task instructions, \( F(4, 1156) = 0.764, p = .549, \eta^2 = .003 \), indicating that there was not a significant difference between participants given RTC, RTI, or RTI+U instruction on the measures of large-grain integration. There was, however, a significant effect of text type, \( F(2, 578) = 13.444, p < .001, \eta^2 = .044 \), indicating
that participants who read a single combined text had higher large-grain integration scores than participants who read two separate texts. This finding suggests that participants who read a single combined text compared to participants who read two separate texts had an increase in large-grain integration scores, but directing college student readers’ attention to integrate was not sufficient to impact large-grain integration.

In order to fully test the hypothesis that instructions to integrate would improve college students’ performance on this large-grain measure of integration, a follow-up analysis was conducted in which only those participants who were able to correctly verify the task instructions were included, for both the RTC and RTI conditions. No participants were removed from the RTI+U condition because all participants in this condition completed understanding questions after the verification task was completed. This resulted in 169 remaining participants in the RTC condition and 124 remaining participants in the RTI condition, and 190 in the RTI+U condition. The resulting means and standard deviations for free recall measures scores are shown in Table 3.15

Table 3.15

<table>
<thead>
<tr>
<th></th>
<th>RTC Combined Text (n=80)</th>
<th>RTI Combined Text (n=58)</th>
<th>RTI+U Combined Text (n=95)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two Texts (n=89)</td>
<td>Two Texts (n=66)</td>
<td>Two Texts (n=95)</td>
</tr>
<tr>
<td>vFRI</td>
<td>1.76 (0.73)</td>
<td>1.69 (0.75)</td>
<td>1.71 (0.72)</td>
</tr>
<tr>
<td>dFRI</td>
<td>1.75 (0.54)</td>
<td>1.79 (0.52)</td>
<td>1.69 (0.60)</td>
</tr>
</tbody>
</table>

A 2 x 2 MANOVA assessed the effect of task instructions and text type on the both large-grain integration measures. All assumptions were again assessed and met. The use of the biology prior knowledge was not used as a covariate, because it did not meet the requirements.

There was not a significant interaction between task instructions and text type, $F(4, 952) = 1.210, p = .305, \eta^2 = .005$, indicating that the effect of task instruction was consistent across both text orders. There was not a significant effect of task instruction, $F (4, 952) = 0.783, p = .536 \eta^2 = .003$, indicating that there was not a significant difference between participants given RTC, RTI, or RTI+U instructions on the large-grain integration measures. There was, however, a significant effect of text type, $F(2, 476) = 8.293, p < .001, \eta^2 = .034$, indicating that participants who read a single combined text had higher integration scores on the large-grain integration measures.
than participants who read two separate texts. This further confirms that directing college student readers’ attention to integrate was not sufficient to impact large-grain integration.

**Relationship between task instruction, integration, and individual differences.**

Hierarchical multiple linear regression tested if Need for Cognition (NFC) significantly predicted participants’ IVT scores, after removing the variance from both SVT measures. The assumption of homoscedasticity was met through visual inspections of the histogram, p-p plot, and scatterplot of the regression standardized residual. Tolerance was checked, and multicollinearity was not problematic. Need for Cognition accounted for unique variance in participants’ IVT scores after the variance for the SVT measures was removed, but the Test of Relational Reasoning was excluded from the model (see Table 3.16).

Table 3.16

**Regression table for Need for Cognition and the IVT measure**

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE (B)</th>
<th>β</th>
<th>ΔR²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocrine SVT</td>
<td>.061</td>
<td>.040</td>
<td>.067</td>
<td>.041*</td>
</tr>
<tr>
<td>Urinary SVT</td>
<td>.153</td>
<td>.039</td>
<td>.173*</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td>.017*</td>
</tr>
<tr>
<td>Endocrine SVT</td>
<td>.052</td>
<td>.040</td>
<td>.057</td>
<td></td>
</tr>
<tr>
<td>Urinary SVT</td>
<td>.143</td>
<td>.039</td>
<td>.162*</td>
<td></td>
</tr>
<tr>
<td>Need For Cognition</td>
<td>.014</td>
<td>.004</td>
<td>.131*</td>
<td></td>
</tr>
</tbody>
</table>

*p<.05; Relational reasoning was excluded from the model in Step 2.

A follow up analysis explored the possibility of NFC as a moderator of task instruction for each of the three measures of integration. Task instruction and the centered NFC scores were entered into Step 1, and the interaction term between centered NFC scores and task instruction was added to Step 2. When looking at vFRI, the model with the interaction term, explained a significantly greater amount of variance, ΔR² = .009, F Change(1, 573) = 5.120, p = .024, and the interaction between NFC and task instructions was significant, β = .152, t(573) = -2.263, p = .024. The analysis was replicated including only participants who successfully verified the task instructions, and the pattern of results was the same. This is a noteworthy finding—Need for Cognition moderated the relationship between the task instructions and the vFRI measure.
When looking at dFRI, the model with the interaction term did not explain a significantly greater amount of variance, $\Delta R^2 = .000$, $F$ Change$(1, 573) = 0.133$, $p = .715$, and the interaction between NFC and task instruction was not significant, $\beta = -.024$, $t(573) = -0.365$, $p = .715$. When looking at the IVT measure, the model with the interaction term, did not explain a significantly greater amount of variance, $\Delta R^2 = .000$, $F$ Change$(1, 573) = 0.011$, $p = .915$, and the interaction between NFC and task instruction was not significant, $\beta = .007$, $t(573) = 0.107$, $p = .915$. The analysis was replicated including only participants who successfully verified the task instructions, and the pattern of results was the same for both of these measures.

**Conclusion**

The results from Experiment 2 offer no evidence that providing students with instructions to integrate between two systems is sufficient for promoting integration. This is particularly salient, because each of these analyses was confirmed when considering only participants that knew the instructions. Furthermore, in Experiment 2, even participants who were provided additional support encouraging *understanding* of the integration task did not score significantly higher on measures of integration than those who were not given the understanding support. That participants who read the combined text did obtain higher scores on the large-grain measure of integration than did participants who read the separate texts indicates that experimental instructional tasks did not effectively promote self-generated integration.

Against the background of Experiments 1 and 2, it is clear that ensuring students know of the goal to integrate, and understand that goal, is not a sufficient means of promoting integration across texts. Because of the concern with low reliability and power, further support for this claim can be evidenced upon inspecting the confidence intervals and effect size of the integration measures across both Experiment 1 and Experiment 2. See Figure 3.11 for comparisons of the instruction condition confidence intervals for the IVT measure across both Experiment 1 and Experiment 2. Also, see Figure 3.12 for comparisons of the instruction condition confidence intervals for the vFRI and dVRI measures in Experiment 2.
Finally, inspection of the aforementioned effect sizes (i.e., $\eta^2 = .001$ to $\eta^2 = .003$) suggests that these differences are not meaningful. It appears that students need additional support to be shown how to integrate. Experiment 3 tests the effects of an intervention designed to provide this support.
Chapter 4

Experiment 3

The findings from Experiment 1 revealed that participants who read RTI instructions did not perform higher on measures of integration than participants who read RTC instructions. This pattern was replicated in Experiment 2, even though some participants given RTI instructions were provided with additional understanding support to ensure the delivered instructions to integrate were understood. Based on these two studies, there is no reason to believe that providing students with task instructions is sufficient to influence integration of multiple texts. While there were reliability challenges for the measures of small-grain integration in both of the aforementioned experiments, the impact of a combined text on large-grain integration indicated that participants who read two separate texts integrated less than participants who read a single combined text. These studies suggest that students require more extensive support to construct integrated knowledge representations when reading separate, but related, texts. Thus it is likely that students require the types of support provided by specific interventions designed to support integration, such as writing arguments and intertext essays (Gil et al., 2010a; 2010b; Wiley & Voss, 1999; Cerdan & Vidal-Abarca, 2008).

Experiment 3 tests this hypothesis by evaluating the effect of an integration-supporting intervention on students’ integration across two biology systems. This intervention is compared to one designed to improve comprehension within a single system. This comparison determines if an integration intervention is sufficient to improve students’ integration on integration-dependent posttest scores. An important requirement of this intervention is that providing support for integration does not adversely impact comprehension. The goal of this experiment is to assess whether participants given an intervention that is focused on improving integration obtain higher integration scores than participants given an intervention that is focused on improving comprehension.

The design of the integration intervention was guided by the belief that this intervention had to meet several criteria. First, the intervention had to meet the requirements identified in Chapter 1 of this dissertation. Namely, the intervention should be designed to minimize instructor demands, be adaptable for existing course reading materials, and take a form that can be completed outside of class. In this respect, the intervention tested here is one that can
likely generalize to the classroom although the current experiment takes place under more controlled conditions. Second, the intervention should prompt and support the identification and comprehension of important elements. Afflerbach and Cho (2009) included this as one of the major categories of effective methods for generating connections in multiple-text environments. Identifying and learning important information encourages readers to compare and contrast between texts, particularly through organizing related information between the texts, identifying common themes, recursive reading of the texts, and effective note taking. Third, the intervention should stimulate monitoring and evaluation. These metacognitive supports are also recommended as a way of enhancing readers’ generation of connections between multiple texts (Afflerbach & Cho, 2009). By changing the focus of strategic processing from comprehension to multiple-text integration and providing readers with tools for managing and detecting comprehension problems, readers’ ability to integrate will be improved. Fourth, an intervention must act to lessen the cognitive load created by integration demands. Providing students with an intervention could increase cognitive load thus impeding integration. Bråten and Strømsø emphasize difficulties faced by readers in multiple text situations:

[I]t can be assumed that the construction of coherent mental representations from the reading of multiple texts requires considerable intentional strategic effort. In general, the comprehension of multiple texts puts considerable demands on readers’ working memory resources as well as on their ability to create bridging inferences. (2011, p. 112)

One intervention that can be easily adapted to meet all four criteria is Kiewra’s SOAR strategy (2005; 2009). The SOAR strategy stands for Selection, Organization, Association, and Regulation. The second criteria listed above, prompting and supporting the identification and comprehension of important elements, is met through the first three components of Kiewra’s SOAR. The process of selecting information during note taking is the foundation of SOAR. Kiewra suggests using matrix frameworks to facilitate students’ concept identification (i.e., selection; 2009). The provision of categories serves to facilitate the selection of important information in a form similar to skeletal notes (Kiewra, 2009; Kiewra, Benton, Kim, Risch, & Christensen, 1995). By organizing the important information into matrices, the relationships between them become evident. “Matrices show comparative relationships,” and are particularly appropriate for “comparing two or more things” (Kiewra, 2005, p. 58). Additionally, Kiewra (2005) emphasized the importance of using the matrix frameworks to facilitate generating
associations from the content through internal (within the informational material) and external (prior knowledge) associations when learning content (cf. Mayer, 1996). The third requirement, stimulating monitoring and evaluation, is met through the final component of the SOAR model, regulation. Kiewra (2005) uses both goal setting and evaluation (cf. Winne & Hadwin, 1998) to facilitate readers’ regulation processes. In particular, use of both teacher-provided and student-generated practice tests are encouraged to help students monitor progress. Finally, the fourth requirement, lessening the cognitive load, is met through the use of external note-taking. By using a matrix framework as a form of external note-taking, readers are not required to hold the information from the both systems in working memory. Readers can take notes from the first text and refer back to these notes as needed during reading of the second text.

Adaptation of the SOAR method for biology content also meets the first criteria described above. The demands placed on the instructor are limited to development of the initial matrix and a set of association questions for each to-be-integrated topic. In addition, the intervention is one that students could complete independently while completing assigned course readings. In short, an intervention based on SOAR principles is one that could easily be adapted to generalize from a controlled experimental setting to the classroom.

A study by Jairam and Kiewra (2009) has demonstrated empirical benefits of the SOAR strategy. Participants who studied using the SOAR strategy were better able to draw relationships than participants who studied without the SOAR strategy. Two types of outcome measures were assessed: a fact test measured participants’ ability to recall facts from the text and a relationship test measured the relationships that participants generated in response to open-ended questions. There were no differences between the groups on the recall of facts, but participants who studied using the SOAR strategy generated more relationships than participants who studied without the SOAR strategy.

A previous effort to adapt SOAR principles to more complex materials for college students has also shown the promise of this approach. Turns et al. (in prep) developed an intervention for students enrolled in a thermodynamics course that was based on these cognitive processes. The research was aimed at facilitating students’ ability to reason through quasi-equilibrium processes related to use of the First Law of Thermodynamics. A matrix framework was developed to provide students with a note-taking tool. Three processes (i.e., pressure, volume, and temperature) were provided in the rows, and eleven columns were provided (e.g., plots, equations, moving boundary
work, heat, etc.). Subsequently, students responded to a set of associative questions that required generating associations between the rows and columns of the matrix. Responding to the associative questions required integration and generation of connections between the cells of the matrix. Participants who completed the matrix framework and associative questions scored significantly higher than participants who completed traditional homework problems on a measure of thermodynamics reasoning. Data from a follow-up study verified the benefits of the targeted study techniques. Fifteen participants thought aloud during completion of the matrix framework and associative questions. Participants exhibited more elaborative processing during completion of the associative questions than the matrix framework, and there was a significant positive correlation between posttest scores and both the number of elaborations and regulations.

In sum, the SOAR strategy was selected as the basis for the intervention in this study because it meets each of the desired criteria. Not only is it adaptable to the classroom, but the SOAR principles can be used to prompt students to build relationships and connections between concepts. In addition, these principles are congruent with the recommendations for effective text integration strategies that were outlined by Afflerbach and Cho (2009).

**The Present Study**

Experiment 3 tests an intervention designed to support integration. The effects of this integration intervention are compared to a second intervention that is similar, but targets single-text comprehension. A control task comparison group is also included for purposes of evaluating the two interventions. The integration intervention, *inspiring integration* (II) was modeled after the principles of SOAR. Specifically, participants in the II condition complete an integration matrix while studying the same text(s) used in Experiments 1 and 2. The II intervention is designed to fulfill each of the three requirements described earlier by: (1) prompting and supporting the identification and connections of important and related information between the endocrine and urinary systems, (2) stimulating monitoring and evaluation toward the task of integration, and (3) lessening cognitive load by providing external notes for students to use while reading about the endocrine and urinary systems.

In contrast to the II condition, participants in the *coaching comprehension* (CC) condition also receive an intervention. The CC intervention, however, is aimed solely at comprehension of the text explaining the endocrine
and urinary systems. The CC intervention includes an equivalent comparison to the II intervention by: (1) prompting and supporting the identification of important concepts within each of the endocrine and urinary systems, (2) stimulating monitoring and evaluation toward the task of comprehension, and (3) lessening cognitive load by providing external notes for students to use while reading about the endocrine and urinary systems.

The final condition used in Experiment 3 is a control task condition (CT) in which participants receive a note-taking task. The CT includes an equivalent comparison to the II and CC interventions by: (1) prompting and supporting the identification of important concepts without respect to integration or comprehension, (2) lessening cognitive load by providing external notes. There was no stimulation of monitoring or evaluation as part of the CT.

The three conditions in this experiment test the efficacy of an intervention designed to support integration specifically. By comparing performance on both comprehension and integration measures across these three conditions, it is possible to determine if an integration-supporting intervention (i.e., II) aids students’ generation of between system integration, beyond the benefits gained by either improved comprehension of each system or identification of key elements.

Consistent with Experiment 2, Experiment 3 also includes the same text type conditions. Half of the participants read a single, combined text and half of the participants read the two separate texts. Comparisons across these conditions can determine if the II intervention stimulates the integration of concepts between systems beyond that prompted by the presentation of concepts within a single text. Experiment 3 is also divided into two different studies, Experiment 3a and Experiment 3b. Whilst the methods of these two studies are identical, the populations are different. Experiment 3a includes participants drawn from a college biology course that included a majority of non-biology majors. Experiment 3b, by contrast, includes participants drawn from a course comprised mostly of students enrolled in biology-related majors (e.g., pre-med). Given these differences in academic majors, it would be expected that there would be differences in biology prior knowledge (n.b., statistical comparison of prior knowledge scores between participants recruited from the two different courses confirmed this prediction). Furthermore, participants in Experiment 3a had additional motivation to participate in the research. During recruitment for Experiment 3a, participants were informed that participating in the research would help them with upcoming clicker questions in the class. Accordingly, results from the two experiments are presented separately, and as such Experiment 3b serves as a
replication of the Experiment 3a. Experiment 3b also tests whether the effects of Experiment 3a extend to a population that is more familiar with learning from biology materials.

Experiments 3a and 3b both use the same measures of text comprehension and text integration that were used in Experiment 2. A self-report measure of strategy use is also included. This measure, the Integration and Separation Strategy Inventory (ISSI), is adapted from Bråten and Strømsø’s (2011) Multiple-Text Strategy Inventory (MTSI). Whereas the MTSI is a self-report measure of integration and comprehension strategies used while reading separate texts that cover a related topic from different perspectives, the ISSI measures the use of these strategies when reading about different, but related, biological systems. This measure was added to Experiment 3 to test whether participants in the different experimental conditions actually reported engaging in different learning strategies.

Hypotheses

The research hypotheses for the Experiment 3 studies are:

1) **Participants provided with support specific to text comprehension will score higher on measures of comprehension than participants who were not provided with support specific toward text comprehension.**

   It is expected that participants who are given the CC intervention will have higher scores on both of the comprehension measures than participants in either the II or CT conditions. This main effect for the intervention is hypothesized because participants who are in the CC intervention are provided with support directly targeting comprehension of the text(s). Thus, participants in the CC condition are expected to score significantly higher on both small-grain and large-grain comprehension measures than participants in the II and CT not given this support. There is not a main effect predicted for text type, nor is there a predicted interaction between intervention condition and text type on comprehension measures.

   2) **Participants who received integration support will score higher on measures of integration than those who are not given integration support.**

   It is expected that participants in the II condition will have higher scores on both measures of integration than participants in either the CC or CT conditions. This main effect of intervention is hypothesized because participants in the II condition are provided support that directly targets text integration, thus it is expected to result
in higher scores on both small-grain and large-grain integration measures than participants in either the CC or CT conditions.

3) **Participants who read a single combined text will score higher on measures of integration than those who read two separate texts.**

Additionally, it is expected that participants who read a single, combined text will have higher scores on both measures of integration than participants who read two separate texts. This main effect for text type is hypothesized because participants who read a single, combined text are provided with information from both systems in near proximity, and thus resulting in higher scores on both small-grain and large-grain integration measures than participants who read two separate texts.

4) **The results of the main effects of Hypothesis #2 and Hypothesis #3 will be qualified by the interaction between intervention and text type.**

An interaction is hypothesized between intervention condition and text type is expected to qualify the interpretation of the main effects. It is predicted that participants receiving either the CC intervention or the CT and two separate texts will have lower scores on both measures of integration than participants in the other four conditions.

5) **There will be an effect of intervention condition on subscale scores of the ISSI. Specifically, II participants will obtain the highest scores overall on the subscale measuring integration strategies. Additionally, II participants will obtain the lowest scores overall on the subscale measuring separation strategies.**

Participants in the II condition are given the goal of integration along with an intervention to aid integration. A main effect of intervention on the integration strategies subscale of the ISSI is expected because II participants are expected to engage integration strategies more frequently than participants in either of the other two conditions. Participants in the II condition are also expected to engage in separation strategies less frequently than participants in either of the other two conditions.

6) **The effect of the intervention condition on integration scores will be mediated by ISSI integration subscale.**

As a result of the effects predicted in Hypothesis #5, the ISSI integration subscale is expected to mediate the effect of intervention condition on integration measures. Participants who report the most frequent use of integration strategies are expected to have the highest scores on measures of integration regardless of condition assignment.
Experiment 3a

Method

Participants.

Participants were 170 (121 female) students recruited during the spring 2013 semester from Biology 141, an introductory biology course. This is the same course from which participants were drawn for Experiment 2. One participant was removed from analyses for not completing all measures (e.g., leaving the study session early). Participants ranged in age from 18 to 26, with the majority of participants being 18 (26.0%), 19 (39.6%), 20 (17.8%), or 21 (6.5%); few participants were 22 and over (10.1%). The majority of participants identified as White (72.8%), with the remaining participants identifying as Asian (8.9%), Black (8.9%), Pacific Islander (1.8%), and Hispanic (4.1%). Several participants indicated “other” (2.4%) or did not respond (1.2%). Participants represented a range of semester standing: freshman (0 – 1 semesters completed; 48.5%), sophomore (2 – 3 semesters completed; 26.6%), junior (4 – 5 semesters completed; 14.2%), senior (6 – 7 semesters completed; 8.9%), and greater (8 – 16 semesters completed; 1.8%). Self-reported grade point average (GPA) ranged from 1.19 to 4.2 with the mean GPA of 3.11 (SD = 0.58). Of the 149 participants who reported a valid Verbal SAT score, the mean was 591.1 (SD = 78.7). Most participants reported English as their first language (93.5%). Approximately one-third of the participants reported being in a biology-related major (33.8%), while the remaining reported non-biology related majors (e.g., psychology, kinesiology, nutrition, and engineering). Participants were roughly comparable to those in Experiments 1 and 2. Participants reviewed and gave Implied Consent electronically prior to beginning the study. [See Appendix C for a copy of the Implied Consent Document used in Experiment 3a.]

Design.

Participants were randomly assigned to one of six conditions in a 3 (intervention condition) x 2 (text type) experimental design. The three intervention conditions were: inspiring integration (II), coaching comprehension
(CC), and control task (CT). The two text types were: two separate texts (S) and a combined text (C). Thus, the six conditions were: inspiring integration with two separate texts (II-S), inspiring integration with a combined text (II-C), coaching comprehension with two separate texts (CC-S), coaching comprehension with a combined text (CC-C), control task with two separate texts (CT-S), and control task with a combined text (CT-C). Dependent measures assessed comprehension and integration via the same measures used in Experiment 2. All participants also completed three individual difference measures: biology prior knowledge, Need for Cognition (NFC), and ISSI.

**Materials.**

**Individual difference measures.**

*Demographics.* The demographic questions were unchanged from Experiment 2.

*Biology prior knowledge.* The 10-item biology prior knowledge measure was the same as that used in Experiment 2 ($\alpha = .256$).

*Need for Cognition.* The 18-item Need for Cognition (NFC) measure was the same as that used in Experiment 2 ($\alpha = .886$).

**Knowledge measures**

*Comprehension measures.*

*Small-grain text comprehension: Sentence verification technique.* The SVT measures were unchanged from Experiment 2. The reliability of scores was not improved from Experiment 2, internal consistency for the 16-item measures were still rather low: the endocrine system, $\alpha = .403$, and the urinary system, $\alpha = .300$.

*Large-grain text comprehension: Principle identification technique.* The items on the PIT measures were unchanged from Experiment 2. After reverse coding for different deep structure items, the sum across the four items was calculated, resulting in a range of scores between -40 and +40. The reliability of scores was not improved from
Experiment 2, internal consistency for the four-item measures were still rather low\(^1\): the endocrine system, \(\alpha = .195\), and the urinary system, \(\alpha = .324\).

Integration measures.

Small-grain integration: Inference verification technique. The IVT measure was unchanged from Experiment 2. The reliability of scores was not improved from Experiment 2, internal consistency was unacceptably low\(^1\), \(\alpha = .030\).

Large-grain integration: Free recall.

Verbal free recall integration. The verbal free recall integration (vFRI) measure was unchanged from Experiment 2. The responses were coded into the 4-point rubric measuring large-grain integration. Inter-rater agreement was established on 20% of the participants’ responses; the two raters achieved 88% agreement. Two raters each independently coded 50% of the remaining responses.

Drawing free recall integration. The drawing free recall integration (dFRI) measure was unchanged from Experiment 2. The responses were coded into the 4-point rubric measuring large-grain integration. Inter-rater agreement was established on 20% of the participants’ responses; the two raters achieved 92% agreement. Two raters each independently coded 50% of the remaining responses.

Integration and Separation Strategy Inventory (ISSI). The ISSI is a measure of self-reported strategy use adapted from the Multiple-Text Strategy Inventory (MTSI; Bråten & Strømsø, 2010). The MTSI was constructed to identify two subscales of readers’ self-reported strategy use when reading multiple texts: knowledge accumulation and cross-text elaboration. The knowledge accumulation subscale measures readers’ efforts toward the accumulation of knowledge within single texts, while the cross-text elaboration subscale measures readers’ efforts toward the integration and connections developed between the different texts. Unfortunately, the MTSI is applicable only to situations where readers are faced with multiple texts that cover the same topic from different perspectives. Bråten & Strømsø, (2010), for instance, used the MTSI in a study in which participants read seven texts that all covered the topic of climate change, and items specifically referred to the concepts covered in the climate change texts.

The MTSI was adapted to fit the current situation in which participants read texts that covered separate, but related, topics. The resulting inventory, the ISSI, was also developed to be equally applicable to both the combined
text and separate texts conditions used in this experiment. The ISSI inventory includes two subscales, comparable to the two subscales of the MTSI. The first subscale, the integration subscale, measures readers’ efforts to integrate concepts between the two biology systems. This subscale contains items, which assess the degree to which participants used strategies directed at drawing connections across the two biological systems. This subscale corresponds to the cross-text elaboration subscale of the MTSI. The second subscale, the separation subscale, measures readers’ efforts to accumulate concepts within each system separately. The separation subscale contains items, which assess how frequently participants used strategies directed at learning about one system independently of the other biological system. This separation subscale corresponds to the accumulation subscale of the MTSI. Regardless of the subscale, all ISSI items referenced learning of the biological system (i.e., endocrine or urinary) rather than texts and thus, the items were equally appropriate for both the combined text and separate texts conditions.

Participants’ responded to all ISSI items on a 10-point likert-type scale (e.g., 1=Not At All; 10=Frequently). Instructions were: “For the following items, rate to what extent you performed the described activity while reading the material.” The integration subscale included eight items (e.g., “I tried to identify facts about how the endocrine and urinary systems work together.”). This subscale was similar to the cross-text elaboration subscale of the MTSI, which measured “deeper-level focusing on comparing, contrasting, and integrating contents” (Bråten & Strømsø, 2010, p. 120). The separation subscale also included eight items (e.g., “I tried to note how the endocrine system has different parts and how the urinary system has different parts.”). Again, this subscale was similar to the accumulation subscale of the MTSI, which measured “superficial focusing on the accumulation of pieces of factual information” (Bråten & Strømsø, 2010, p. 120). However, a notable difference from the MTSI accumulation scale is that, the ISSI separation subscale measured efforts to comprehend factual aspects of each system separately from the other system and not necessarily “superficial focusing”. [See Appendix C for the all ISSI items.]

From the original 16-item MTSI, six items (five integration and one separation) were selected and revised to reflect the current experimental situation. For these items, references to texts were changed to refer to the endocrine and urinary systems. The remaining nine MTSI items could not be revised for the ISSI, either because the item was not applicable (e.g., “I considered whether the texts represented contradictory views on global warming.”), or because the item was largely redundant with other MTSI items (e.g., “I concentrated on remembering as much
factual information as possible from all the texts,” and “I emphasized picking up as much information as possible from all the texts,”). Finally, the original MTSI cross-text elaboration subscale only contained five items. For the ISSI, new items were added so that each subscale contained eight items.

Development for the ISSI began by selecting items from the MTSI that could be revised to reflect the current experimental situation. Once these items were selected, corresponding items were written for the opposing subscale. For example, the MTSI cross-text elaboration item, “I tried to form a complete picture of the consequences that may be caused by climate change.” was revised to fit the current experimental situation as the integration subscale item, “I tried to form a complete picture of the how the endocrine system and the urinary system work together to influence how the human body functions.” Then, a parallel separation subscale item was developed, “I tried to form a picture of how the endocrine system influences how the human body functions separately from how the urinary system influences how the human body functions.” For each of the two subscales, four items were selected or written to assess lower-order strategies (e.g., identification of facts), and four items were selected or written to assess higher-order strategies (e.g., analysis). To account for possible confounds, items in both subscales were parallel, with differences tapping process of either integration or separation. Ultimately, both ISSI subscales reference both lower-order, basic skills (e.g., Integration: “I tried to identify facts about how the endocrine and urinary systems work together.”) as well as the higher-order advanced skills of that subscale (e.g., Integration: “I tried to form a complete picture of the how the endocrine system and the urinary system work together to influence how the human body functions.”). All items used similar wording, and each began with “I tried to…”.

An exploratory factor analysis (EFA) was conducted on the ISSI to examine the subscale structure of the measure. The values for the two subscales were derived from factor scores. Three items were removed; the Integration Factor was comprised of seven items, $\alpha = .850$, and the Separation Factor was comprised of six items, $\alpha = .759$. More information regarding the EFA is reported in the Results section.
Open-ended comments (optional).

An optional open-ended response measure was also included. This item, which is the same as the item delivered in Experiments 1 and 2, asked participants to include any additional comments or concerns regarding the study.

Independent variables.

Experimental Texts.

The experimental texts were unchanged from Experiment 2. Half of the participants received two separate, texts (S), that were counterbalanced. The other half of the participants received the texts in the single combined form (C). Participants in the single combined text conditions received instructions that referred to the text in singular form; participants the separate text conditions received instructions that referred to the texts in plural form.

Intervention Condition.

Instructional materials included three different interventions corresponding to the two interventions and the control task. The materials provided a parallel experience for participants across the three conditions, although the specific materials differed according to condition. In addition, materials for all three conditions included the enhanced +understanding instructions tested in Experiment 2. Finally participants in all three conditions received the corresponding materials at the start of the session and worked through the assigned intervention while reading the experimental text(s).

Inspiring Integration (II). The II intervention was designed to enhance the integration between concepts presented in the text(s), by providing both task instructions to integrate with the addition of support to help participants accomplish integration between the two biology systems. The II intervention included revised instructions and understanding questions from the RTI+U condition presented in Experiment 2. Minor revisions
were required to ensure all three conditions received parallel instructions in Experiment 3. See Figure 4.1 for the final version of II instructions and Figure 4.2 for the final version of the II+U questions.

**Figure 4.1** Instructions for II condition. *Note:* above instructions correspond to participants assigned to the separate texts condition, participants who received a single combined text received wording that referred to a single text.
In addition to the instructions to integrate, and understanding questions, participants also received a three-part worksheet. This worksheet was adapted from Kiewra’s SOAR method (2005; 2009). Part 1 of the II intervention was comprised of a single worksheet and included a single matrix in which participants could enter notes from the text(s) by writing this information into the appropriate matrix cells. The framework directed participants to select and organize content from the text(s). Participants received the matrix shown in Figure 4.3 along with instructions; “Select important content and paraphrase it into the boxes below to organize the
information.” As can be seen in Figure 4.3, columns of the worksheet included both the endocrine system and the urinary system. These columns were placed side-by-side to draw attention to the relations between the systems.

<table>
<thead>
<tr>
<th>Identify and describe the structures of the system.</th>
<th>Urinary System</th>
<th>Endocrine System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the purpose of the system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explain how the structures work together to achieve the purpose.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Describe how the body remains in homeostasis.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 4.3 Part 1 of the II worksheet: a selection and organization tool. A matrix framework with supplied topics and categories for participants to fill in the details of the text(s).*

Part 2 of the II intervention was comprised of a worksheet that presented a series of *association* questions. These association questions required participants to use information that had been entered into different cells of the matrix from Part 1 and generate connections, or associations, across these cells. This method is consistent with Kiewra’s (2005) recommendation that learners be explicitly prompted to generate associations across content. The instructions for Part 2 were:
Use your notes to create *associations* between related ideas from the material. Think of this as if the information you learned are pieces of a puzzle, and your goal is to assemble one large puzzle.

Three association questions were included in this part of the II intervention. There were two specific and one general association questions. The three questions were:

1. How does the Endocrine System influence the Urinary System?
2. How does the Urinary System influence the Endocrine System?
3. Can you generate any other associations?

Part 3 of the II intervention was a regulation prompt (Ifenthaler, 2012). Specifically, after completing Parts 1 and 2 of the intervention, II participants were presented with the question, “Do you recall the instructions you read at the very beginning of the study? You were asked to integrate and connect between the endocrine and urinary systems.” Following this, participants were directed to engage in practice testing by responding to the request to, “Generate one question that you think might be asked later in the study that tests whether or not you were able to accomplish integrating the two systems.” Finally, participants were asked to “Reflect on whether or not you have studied the materials to integrate between these concepts. Look back at the notes you have taken if necessary.” Collectively, these prompts from Part 3 address the regulation component of the SOAR method. Specifically, regulation is supported by explicitly providing objectives prior to task engagement (Kiewra, 2005) and reminding participants of these objectives at the end of the task while encouraging evaluation for the degree to which these objectives were obtained.

*Coaching Comprehension.* The CC intervention was designed to enhance the comprehension of the concepts presented in the text(s), by providing both task instructions to comprehend with additional support to help participants accomplish comprehension. The CC intervention included revised instructions from the RTC condition presented in Experiment 2. There were minor revisions to the RTC instructions from Experiment 2 to allow for the addition of the +understanding task in Experiment 3 and to ensure all three conditions received parallel instructions in Experiment 3. The CC intervention also included an equivalent +understanding comprehension practice component. See Figure 4.4 for the final version of CC instructions, and Figure 4.5 for the final version of the II+U questions.
**INSTRUCTIONS: READ CAREFULLY**

You will be asked to read two different biology texts, read each one as if you were studying for a test in your course. Each text has a number of biology concepts that are covered. While you are reading each text, try to study the concepts and comprehend each one to the best of your ability.

Research has shown that if you understand each text, you may be able to learn more than if you don’t.

**Figure 4.4** Instructions for CC condition. *Note: above instructions correspond to participants assigned to the separate texts condition, participants who received a single combined text received wording that referred to a single text.*

---

Since the purpose of reading the two biology texts is to study the concepts and comprehend each one to the best of your ability, it is important that you understand what this means.

Use the text box below to describe *in your own words* what it means to understand each text.

---

**Please read the example excerpt and practice understanding it.**

In the text box below, write out what you understand the example excerpt to mean.

**Example Excerpt:**

Some dogs have a “double coat” that is made up of two parts, a soft undercoat that keeps them warm, and a coarse top coat that repels water. In the spring, many pet owners bring their dog to the groomer to brush out the undercoat and trim the top coat to avoid excessive shedding.

---

**Figure 4.5** Two questions that followed the task verification item as part of the understanding comprehension practice for II condition, to ensure all CC participants *understood* the instructions. *Note: above instructions correspond to participants assigned to the separate texts condition, participants who received a single combined text received wording that referred to a single text.*

In addition to the instructions to comprehend, and understanding questions, participants also received a three-part worksheet. This worksheet was adapted from Kiewra’s SOAR method. All three parts of the CC worksheet were equivalent to the II worksheet, but instead it focused participants’ attention on comprehension of the
single topics within the endocrine and urinary systems. Part 1 of the CC intervention was comprised of two worksheets and included a provided outline that helped participants take notes from the text(s). They received the outline shown in Figure 4.6. The same categories from the II matrix framework were re-structured so that the category prompts were presented twice, once for each system. Instead of presenting the systems side-by-side, the information from each system was presented on two sides of the same page (i.e., double sided printing).

![Figure 4.6 Part 1 of the CC worksheet: an outline with supplied categories for participants to fill in notes from the text(s) on the front and back of a piece of paper.](image)

Part 2 of the CC intervention was comprised of a worksheet that presented a series of detail oriented, open-ended comprehension questions that encouraged comprehension of information from each text. Each question could be answered by locating a specific term in the text and defining/describing that concept. Care was taken during question development to use content unlikely to prompt integration. The instructions and questions for Part 2 were:

Answer the following questions:

a.  Endocrine System:
   1)  Describe how monoamines transport to a target cell.
   2)  Describe the appearance of the pituitary gland.

b.  Urinary System:
   1)  What is Bowman’s capsule?
2) How much, and how concentrated, is the urine that is produced by the kidneys?

Part 3 of the CC intervention was a regulation prompt (Ifenthaler, 2012). Specifically, after completing Parts 1 and 2 of the intervention, CC participants were presented with the question, “Do you recall the instructions you read at the very beginning of the study? You were asked to comprehend the material.” Like participants in the II intervention, participants in CC intervention were then directed to engage in practice testing by responding to the request to, “Generate one question that you think might be asked later in the study that tests whether or not you were able to accomplish comprehending.” Finally, participants were asked to, “Reflect on whether or not you have studied the materials to comprehend. Look back at the notes you have taken if necessary.”

Control Task (CT). The new CT was designed to deliver an equivalent task without providing intervention toward either comprehension or integration. The CT instructions were equivalent to the instructions in the II and CC conditions, but focused participants on identifying important information. An equivalent +understanding the control practice component was also developed. See Figure 4.7 for the newly developed CT instructions, and Figure 4.8 for the newly developed +understanding practice items for CT.

Figure 4.7 Instructions for CT condition. Note: above instructions correspond to participants assigned to the separate texts condition, participants who received a single combined text received wording that referred to a single text.
In addition to the instructions for the CT, and understanding questions, participants also received a two-part worksheet. Both parts of the worksheet corresponded to Part 1 and Part 2 of the II and CC worksheets, but focused participants’ attention on selection and identification of concepts, without facilitating comprehension or integration. Part 1 of the CT was comprised of two worksheets and included an outline to structure participants’ note-taking from the text(s). They received the outline shown in Figure 4.9. General categories were selected to correspond to the headings in the text(s). The information from each system was presented on two sides of the same page (i.e., double sided printing), like the CC intervention condition worksheet.

**Figure 4.8** Two questions that followed the task verification item as part of the understanding the control practice for CT condition, to ensure all CT participants understood the instructions. Note: above instructions correspond to participants assigned to the separate texts condition, participants who received a single combined text received wording that referred to a single text.
Part 1 of the CT worksheet: an outline with general categories for participants to fill in notes from the text(s) on the front and back side of a piece of paper.

Part 2 of the CT was comprised of a worksheet that presented a series of general, open-ended questions without a correct answer. Care was taken during question development to avoid prompting either comprehension or integration. The instructions and questions for Part 2 were:

Consider the text
What was the most important piece of information from “Introduction to the Urinary System”?
What was the most important piece of information from “Introduction to the Endocrine System”?
What was the most important piece of information from “Organs of the Urinary System”?
What was the most important piece of information from “Glands of the Endocrine System”?
What was the most important piece of information from “How the Urinary System Works”?
What was the most important piece of information from “How the Endocrine System Works”?

Participants in CG did not receive a regulation prompt. As such there was not an equivalent to the regulation prompt provided to participants in the II and CC interventions.
Procedures.

During recruitment, students in Biology 141 were informed that participation in the study was voluntary and that they would receive credit in their biology course for participation. Specifically, students in this course were able to accumulate extra-credit points by answering clicker questions during course lectures. A total of 100 clicker points were available throughout the semester. Extra-credit for participating in this study was awarded by giving participants five points toward this total of 100 clicker points. Students were informed that the content used in the experiment corresponded to content that would be covered in upcoming lectures and would be included on the final exam. Students were also informed that, at the start of an upcoming lecture, the instructor would present clicker questions based on the experimental materials. The instructor informed all students that participating in the study would give them an advantage on those questions and the subsequent course exam. These manipulations were used in an effort to enhance student engagement during the period of the experiment. This was implemented, as there was concern about participants’ investment in learning the experimental materials from Experiments 1 and 2. Including clicker questions on the experimental content in the class provided an additional incentive to learn from the experimental materials.

Students signed up for one of 10 experimental sessions through an online sign-up system. Sessions were offered at various times over the course of six academic days in reserved computer labs on campus. Sessions were reserved for two-hour slots, with 30 minutes between each session. All participants started at the same time for each session. Computer labs ranged from 30 to 80 computers per lab. Either a faculty member or a graduate student conducted all experimental sessions.

Prior to administration, folders were prepared that contained all materials marked with anonymous identification numbers (i.e., participants’ Study ID). Condition assignment was determined by the contents of the folder. The order of folders was randomized so that participants were randomly assigned to condition within experimental sessions. A script was read at the beginning of each session, accompanied by a PowerPoint slide to ensure all sessions received equivalent instructions regarding study procedures. These instructions were the same as those given in Experiment 2 with three exceptions. First, participants were told how to find their Study ID and enter it on the website. Second, instructions on using the back button were clarified. Third, participants were reminded that the content in the material would be related to upcoming course clicker questions. The script for Experiment 3a
is available in Appendix C. After the verbal script was delivered, participants were instructed to log on to their computers, open Firefox browser, and visit the link to the Qualtrics survey to begin.

After participants gave implied consent, they were instructed to “Please read all instructions very carefully!” and then enter their Study ID. To ensure the Study ID was entered correctly, participants were required to enter the number twice. Qualtrics verified the ID was the same in both entries before allowing the participant to progress. The Qualtrics system used the entered Study ID number, which assigned participants to condition, to ensure the corresponding condition instructions and materials were delivered. Participants completed the instruments in the following order (see Table 4.1).

Table 4.1
Procedures for each of the six conditions

<table>
<thead>
<tr>
<th></th>
<th>II -S</th>
<th>II-C</th>
<th>CC -S</th>
<th>CC -C</th>
<th>CT -S</th>
<th>CT -C</th>
</tr>
</thead>
<tbody>
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<td>Consent</td>
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<td>✓</td>
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<tr>
<td>+Understand</td>
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<td>✓</td>
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<td>Combined</td>
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<td>Inspiring Integration</td>
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<td>Coaching Comprehension</td>
<td>Control</td>
<td>Control</td>
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<td>✓</td>
<td>✓</td>
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<td>Draw Free Recall</td>
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<td>✓</td>
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<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Open-ended Comments</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Results

Preliminary analysis.

Descriptive statistics are presented in Table 4.2. For each of the six conditions, means and standard deviations are provided for both individual difference and dependent measures.
Table 4.2

Master table of means and standard deviations for each of the six conditions

<table>
<thead>
<tr>
<th></th>
<th>Inspiring Integration</th>
<th>Coaching Comprehension</th>
<th>Control Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Combined (n = 25)</td>
<td>Separate (n = 30)</td>
<td>Combined (n = 25)</td>
</tr>
<tr>
<td>Individual difference measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPK</td>
<td>5.32 (1.31)</td>
<td>5.10 (1.81)</td>
<td>4.88 (1.53)</td>
</tr>
<tr>
<td>NFC</td>
<td>11.76 (18.45)</td>
<td>9.37 (25.51)</td>
<td>18.96 (23.88)</td>
</tr>
<tr>
<td>ISSI - Integration</td>
<td>0.59 (0.81)</td>
<td>0.33 (1.04)</td>
<td>-0.02 (0.73)</td>
</tr>
<tr>
<td>ISSI - Separation</td>
<td>-0.19 (0.89)</td>
<td>-0.44 (1.18)</td>
<td>0.18 (0.80)</td>
</tr>
<tr>
<td>Dependent measures</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SVT End.</td>
<td>10.16 (2.38)</td>
<td>9.97 (2.04)</td>
<td>9.96 (2.54)</td>
</tr>
<tr>
<td>SVT Uri.</td>
<td>10.28 (1.72)</td>
<td>9.30 (2.35)</td>
<td>10.00 (1.87)</td>
</tr>
<tr>
<td>PIT End.</td>
<td>26.09 (5.48)</td>
<td>24.16 (5.48)</td>
<td>26.33 (5.38)</td>
</tr>
<tr>
<td>PIT Uri.</td>
<td>27.34 (5.46)</td>
<td>24.97 (6.75)</td>
<td>28.06 (5.20)</td>
</tr>
<tr>
<td>IVT</td>
<td>9.32 (1.80)</td>
<td>8.57 (1.91)</td>
<td>9.52 (1.83)</td>
</tr>
<tr>
<td>vFRI</td>
<td>1.92 (0.95)</td>
<td>1.50 (0.78)</td>
<td>1.52 (0.59)</td>
</tr>
<tr>
<td>dFRI</td>
<td>1.36 (0.81)</td>
<td>1.33 (0.71)</td>
<td>1.44 (0.77)</td>
</tr>
</tbody>
</table>
Time. Qualtrics recorded time spent on the condition specific instructions as well as the text(s). For each of these, time ranges varied widely, and the distributions were positively skewed. Time spent on the instructions ranged from 1.9 seconds to 48.9 seconds. These times were compared across conditions to test the possibility that there is a condition effect on time on task. Statistical outliers were removed using the outlier labeling rule with $g = 2.2$ (Hoaglin & Iglewicz, 1987). These outliers are removed for the time analyses reported here but were retained for all subsequent analyses involved learning and individual difference variables. Figure 4.10 shows the histogram of time distributions on the instructions by intervention condition.

![Histogram of Time Spent on Instructions by Condition](image)

*Figure 4.10 Time spent on instructions per intervention condition.*

For participants who read separate texts, time spent reading the endocrine system text ranged from 2.6 seconds to 42.6 minutes. Corresponding times for the urinary system text ranged from 3.5 seconds to 52.1 minutes. For participants who read a combined text, time ranged from 21.5 seconds to 80.5 minutes. Figure 4.11 compares the time spent for each of the two separate texts; Figure 4.12 shows the time spent on the combined text.
Figure 4.11 Time spent on the endocrine text and the urinary text for participants in the separate texts condition.

Figure 4.12 Time spent on the text for participants in the single combined text condition.
Table 4.3 contains the means and standard deviations for time spent on the instructions for each of the intervention conditions after removing the statistical outliers. Five statistical outliers were identified for time spent reading the instructions; two participants in the CC condition and three participants in the CT condition were removed. A one-way ANOVA tested the differences in time spent on the instructions for each of the three intervention conditions. Despite the trend that participants in the II condition spent approximately two seconds longer reading the instructions than participants in either the CC or CT conditions, there was not a significant difference between conditions on the time spent reading the instructions, $F(2, 162) = 1.85, p = .160$. Compared to Experiment 2, participants spent approximately the same time reading the instructions (13.0 seconds).

Table 4.3

<table>
<thead>
<tr>
<th>Time spent by intervention condition on the instructions and text</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Instructions in seconds</td>
</tr>
<tr>
<td>II               CC              CT</td>
</tr>
<tr>
<td>16.81 (10.42)    14.30 (4.87)    14.50 (6.40)</td>
</tr>
<tr>
<td>Both Separate Texts in minutes</td>
</tr>
<tr>
<td>II               CC              CT</td>
</tr>
<tr>
<td>22.60 (14.74)    22.82 (19.33)    29.03 (18.33)</td>
</tr>
<tr>
<td>Combined Text in minutes</td>
</tr>
<tr>
<td>II               CC              CT</td>
</tr>
<tr>
<td>19.47 (16.66)    13.68 (12.73)    33.55 (23.10)</td>
</tr>
</tbody>
</table>

There were no outliers for time spent on the text(s). See Table 4.3 for the means and standard deviations for time spent on the text(s) for each of the three intervention conditions. A 2 (text type) x 3 (intervention condition) ANOVA tested the differences on total time spent on the text(s). There was a significant difference between the time spent on the text(s) for intervention condition, $F(2, 163) = 8.39, p < .001$, but there was no significant difference between the two text types, $F(2, 163) = 0.877, p = .350$. There was also no significant interaction between text type and intervention condition, $F(2, 163) = 2.081, p = .128$. Post Hoc LSD analysis revealed that CT condition participants spent significantly more time on the texts than participants who received either the CC ($p < .001$) or the II ($p = .004$) interventions. Overall, compared to Experiment 2, participants spent more time reading the endocrine system text, urinary system text, and combined text (8.5 minutes, 7.8 minutes, and 16.8 minutes, respectively).
Effect of intervention condition on comprehension.

Small-grain comprehension.

A 2 (text type) X 3 (intervention condition) MANCOVA assessed the impact of text type and intervention condition on the two SVT scores. All assumptions were assessed and met. Biology prior knowledge was used as the covariate. The correlation between biology prior knowledge and SVT measures was significant for one dependent measure, $r = .151$ (urinary SVT), but not the other, $r = -.051$ (endocrine SVT). Homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and no significant interaction was found. As such, the covariate was used in the analyses to test the effect of intervention condition. Levine’s homogeneity of variance was not significant, $p = .756$ (endocrine) and $p = .573$ (urinary), suggesting the variances for both dependent variables were equal. Box’s M was not significant, $p = .933$, indicating the covariance matrices of the dependent variables are equal across groups, and as a result, Wilkes’ $\lambda$ was interpreted. See Table 4.2 for the SVT means and standard deviations for each of the six conditions and Table 4.4 for the SVT means and standard deviations for each of three interventions collapsed across text type.

There was not a significant main effect for text type, Wilkes’ $\lambda = .996$, $F(2, 161) = 0.316$, $p = .729$, $\eta^2 = .004$, demonstrating that there was no significant difference between participants who read either two separate texts or a single combined text on the SVT small-grain comprehension measures. There was also no significant main effect of intervention condition, Wilkes’ $\lambda = .944$, $F(4, 322) = 2.357$, $p = .054$ $\eta^2 = .028$. This pattern indicates that participants in neither the CC nor the CT condition had a comprehension advantage over participants in the II condition. The text type by intervention condition interaction was also non-significant, Wilkes’ $\lambda = .949$, $F(4, 322) = 2.138$, $p = .076$, $\eta^2 = .026$, demonstrating that the effects of the intervention condition on comprehension scores were consistent across both text types.

Table 4.4

Means and standard deviations for each of the interventions collapsed across text type for both SVT measures of small-grain comprehension

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVT Endocrine</td>
<td>10.05 (2.18)</td>
<td>10.18 (2.36)</td>
<td>11.12 (2.36)</td>
</tr>
<tr>
<td>SVT Urinary</td>
<td>9.75 (2.13)</td>
<td>10.29 (2.14)</td>
<td>10.41 (2.13)</td>
</tr>
</tbody>
</table>
Analysis of the small-grain comprehension measures for participants in the Experiment 3a did not result in significant differences for participants receiving different text types or different interventions. However, further inspection of the means for the intervention condition revealed a trend that favored participants in the CT condition. Though these differences are small, the pattern is consistent across both the endocrine SVT and the urinary SVT measures. Consequently, there is no evidence to support the hypothesis that participants provided with support specific to text comprehension would score higher on measures of single-text comprehension than participants who were not provided this comprehension support. Importantly, there is also no evidence to suggest that presenting students with an intervention intended to aid integration would harm within system comprehension.

Large-grain comprehension.

A 2 (text type) x 3 (intervention condition) MANOVA with biology prior knowledge as the covariate assessed the impact of intervention and text type on the two PIT scores. All assumptions were assessed and met. Biology prior knowledge was tested for use as a covariate. It did not meet assumptions, and subsequently, it was not used in the analysis. Levine’s homogeneity of variance was not significant for the endocrine PIT measure, \( p = .923 \) but was significant for the urinary PIT measure, \( p = .034 \), suggesting the error variance for the endocrine PIT measure is equal across groups, but the error variance of the urinary PIT measure was not. Due to the sample size, MANOVA is robust to violations of homogeneity of variance. Box’s M was not significant, \( p = .506 \), indicating the covariance matrices of the dependent variable are equal across groups, and as a result, Wilkes’ \( \lambda \) was interpreted.

There was no significant interaction between text type and intervention condition, Wilkes’ \( \lambda = .980, F(4, 324) = 0.840, p = .501, \eta^2 = .010 \), indicating that the effects of intervention condition were consistent across both text types on comprehension. There was no significant main effect of intervention condition, Wilkes’ \( \lambda = .980, F(4, 324) = 0.829, p = .508, \eta^2 = .010 \) indicating that participants who were given the CC intervention did not score significantly higher than participants in the CT or the II intervention on large-grain comprehension measures. There was no significant effect of text type, Wilkes’ \( \lambda = .990, F(2, 162) = 0.778, p = .461, \eta^2 = .010 \), demonstrating that participants who read either two separate texts or a single combined text did not perform significantly different on the large-grain comprehension measure. See Table 4.2 for the PIT means and standard deviations for each of the six
conditions and Table 4.5 for the PIT means and standard deviations for each of three interventions collapsed across
text type.

Table 4.5

<table>
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<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
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<td>26.26 (5.52)</td>
<td>24.60 (5.58)</td>
</tr>
<tr>
<td>PIT Urinary</td>
<td>26.05 (6.25)</td>
<td>27.39 (4.77)</td>
<td>26.29 (5.84)</td>
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</tbody>
</table>

These findings indicate that providing college students with an intervention that targets comprehension
does not improve comprehension scores relative to participants who receive either an II or CT condition.
Additionally, it is noted that providing students with an II intervention does not harm large-grain comprehension
compared to participants who were instructed to focus on a comprehension or control task. There is no evidence to
support the hypothesis that participants provided with support specific to text comprehension score higher on
measures of large-grain comprehension than participants who were not provided with support specific to text
comprehension.

**Effects of intervention condition on integration.**

**Small-grain integration.**

An ANCOVA, with biology prior knowledge as the covariate, assessed the impact of text type and
intervention condition on the IVT measure of multiple-text integration. All assumptions were assessed and met. The
correlation between biology prior knowledge and the IVT measure was significant, \( r = .233 \), permitting the use of
this covariate. Homogeneity of regression assessed the interaction between the independent variable and biology
prior knowledge, and no significant interaction was found. Levine’s homogeneity of variance was not significant, \( p = .759 \), indicating equality of variances for the IVT variable.

There was not a significant interaction between text type and intervention condition, \( F(2, 162) = 0.895, p = .410, \eta^2 = .011 \), indicating that the effects of the intervention condition were consistent across both forms of text
type. There was not a significant effect of text type, \( F(1, 162) = 0.865, p = .368, \eta^2 = .005 \), indicating that there was not a significant difference between participants who read either a single combined or two separate texts on the IVT measure. There was also not a significant effect of intervention condition, \( F(2, 162) = 1.883, p = .155, \eta^2 = .023 \), indicating that there was not a significant difference between participants in the inspiring integration intervention, coaching comprehension intervention, or the control task on the IVT integration measure. See Table 4.2 for the IVT means and standard deviations for each of the six conditions and Table 4.6 for the IVT means and standard deviations for each of three interventions collapsed across text type.

Table 4.6

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVT</td>
<td>8.91 (1.88)</td>
<td>9.41 (1.87)</td>
<td>8.78 (1.75)</td>
</tr>
</tbody>
</table>

This finding suggests that providing students with an II intervention was not sufficient to impact their integration as measured by the IVT measure, compared to participants who received the CC or CT intervention conditions. There is no evidence to support the hypothesis that participants who received integration support scored higher on the measure of integration than those who were not given integration support nor was there evidence to support the hypothesis that participants who read a combined text scored higher on the measure of integration than those who read two separate texts. Furthermore, there was not an interaction between intervention and text type. Unfortunately, however, the reliability of scores derived from the IVT measure is quite poor. Accordingly, the lack of a statistical difference between conditions may be due to the large degree of error variance contained within these scores.

**Large-grain integration.**

A 2 (text type) x 3 (intervention condition) MANOVA tested the impact of text type and intervention condition on the two free recall measures of large-grain integration. Biology prior knowledge was not used as a covariate, because it did not meet the requirements. Levine’s homogeneity of variance was significant for one measure \( p < .001 \) (vFRI) but not the other \( p = .396 \) (dFRI), suggesting the error variance for the drawing free recall
integration measure is equal across groups, but the error variance of the verbal free recall integration measure is not. Box’s M was significant, $p < .001$, indicating the covariance matrices of the dependent variables were not equal across groups, and as a result, Wilke’s $\lambda$ was interpreted. While MANOVA is robust to violations with large sample sizes, when the probability of significant differences in Box’s M is less than .001, extreme caution should be used when interpreting the results (Tabachneck & Fidell, 2001). For this reason, the pattern of findings from the parametric MANOVA was confirmed with a follow-up nonparametric Chi Square analysis. While only the results from the parametric MANOVA are reported below, the results pertaining to the Chi Square analysis were consistent with the MANOVA, thus alleviating some concern due violation of the assumption of equality of covariance matrices.

There was no significant interaction between text type and intervention condition, Wilkes’ $\lambda = .996$, $F(4, 324) = 0.157, p = .960, \eta^2 = .002$, indicating that the effects of the intervention condition were consistent across both text types. There was, however, a significant effect of text type, Wilkes’ $\lambda = .912$, $F(2, 162) = 7.862, p < .001, \eta^2 = .088$, indicating that participants who read a single combined text had higher integration scores on the free recall integration measures than participants who read two separate texts. Univariate analyses for text type revealed significant differences on the verbal free recall integration measure, $F(1, 163) = 14.943, p < .001, \eta^2 = .084$, but not the drawing free recall integration measure, $F(1, 163) = 0.339, p = .561, \eta^2 = .002$. There was also a significant effect of intervention condition, Wilkes’ $\lambda = .918$, $F(4, 324) = 3.526, p = .008, \eta^2 = .042$, indicating that there was a significant difference between participants given the different intervention conditions on the free recall integration measures. Univariate analyses for intervention condition again resulted in significant differences on the verbal free recall integration measure, $F(2, 163) = 5.914, p = .003, \eta^2 = .068$, but not the drawing free recall integration measure, $F(1, 163) = 0.883, p = .416, \eta^2 = .011$. Post Hoc LSD analyses of the vFRI measure revealed that II intervention condition participants scored significantly higher than CC ($p = .002$) or the CT ($p = .005$) participants. See Table 4.2 for the FRI means and standard deviations for each of the six conditions and Table 4.7 for the FRI means and standard deviations for each of three interventions collapsed across text type.
Table 4.7

Means and standard deviations of the free recall integration measures for the three intervention conditions

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>vFRI</td>
<td>1.69 (0.88)</td>
<td>1.30 (0.50)</td>
<td>1.34 (0.58)</td>
</tr>
<tr>
<td>dFRI</td>
<td>1.35 (0.75)</td>
<td>1.54 (0.69)</td>
<td>1.45 (0.68)</td>
</tr>
</tbody>
</table>

This finding supports the hypothesis that participants who received an integration intervention would score higher on an assessment of integrated knowledge than would participants who did not receive this intervention. The lack of an intervention by text type interaction indicates that the II intervention supported integration of these biological systems even when the to-be-connected concepts were presented in separate texts. Furthermore, the significant difference between scores of participants in the II and CC conditions indicates that integration of systems requires more than mere comprehension of the individual systems.

Effects of intervention condition on strategy use.

Integration and Separation Strategy Inventory (ISSI).

Creation, development, and assessment of the ISSI were all modeled after Bråten and Strømsø’s (2011) work on the development of the MTSI. Prior to addressing the research hypotheses based on ISSI scores, the dimensionality of the ISSI was assessed in the same manner as the MTSI. A maximum likelihood exploratory factor analysis was performed on the 16 ISSI items for all 169 participants. Oblique rotation (promax) was chosen to account for an expected correlation between subscales. Missing values were replaced with the mean. Unrestricted factor analysis, resulted in four factors with eigenvalues over 1 (explaining 50.6% of the total variance). Further inspection of the produced factor loadings, however, showed that this solution was not interpretable. First, several items loaded on multiple factors and only two items loaded on to the fourth factor. Second, the eigenvalues of the third and fourth factor were just over 1 (i.e., 1.299 and 1.005). Inspection of the scree plot suggested a two-factor solution.
A second EFA, again using maximum likelihood extraction and promax rotation, was run forcing a two-factor solution. These two factors accounted for 40.4% of the variance. Although this solution accounted for less variance than the initial solution, interpretation of the factor loadings was consistent with the two dimensions hypothesized a priori. Seven of the eight integration strategy items loaded onto the first factor above .300 (eigenvalue = 4.412), and seven of the eight separation strategy items loaded onto the second factor above .300 (eigenvalue = 3.132). One integration item failed to load onto either factor (.203 and .265, respectively), and one separation item loaded onto the separation factor at .214 (compared to .064 loading on Factor 1). The loadings of the remaining items in the second factor analysis supported the a priori expectations.

To account for the two items that failed to load adequately onto a factor, a third EFA was run removing these items. The same criteria as the second EFA were used (i.e., maximum likelihood extraction, promax rotation, forcing a two-factor solution). These two factors accounted for 44.9% of the variance. However, inspection of the resulting factor loadings showed the failure of one additional item to load onto either factor. The item had a borderline loading onto the hypothesized Factor 2 (i.e., .302) in the second EFA, but in the third EFA the item failed to load onto either factor (Factor 1 = .215, Factor 2 = .295).

The final EFA used the same criteria as the second and third, but excluded three items (i.e., the two items that failed to load in the second EFA and the one item that failed to load in the third EFA). The two factors from the final EFA accounted for 47.2% of the variance. The factor scores of this EFA were identified as Integration and Separation and saved using the regression method and are used in subsequent discussion of the ISSI. Accordingly, Cronbach’s alpha reliability values reported in the methods section were conducted including the seven integration items that loaded onto the Integration Factor and the six separation items that loaded onto the Separation Factor. See Appendix C for the factor loadings of each item onto the respective factors.

A 2 (text type) X 3 (intervention condition) MANOVA assessed whether there were any differences between conditions on the two scale scores. Text type and intervention condition were entered as independent variables and scores on the Integration and Separation subscales of the ISSI served as the dependent variables. Biology prior knowledge was not used as a covariate because it did not meet the assumptions. Levine’s homogeneity of variance was not significant, \( p = .808 \) (integration) and \( p = .490 \) (separation), suggesting the variances for both dependent variables were equal. Box’s M was significant, \( p = .003 \), indicating the covariance matrices of the
dependent variable were not equal across groups, and as a result, Wilkes’ $\lambda$ was interpreted. MANOVA conducted on large sample sizes is robust to violations of Box’s M up to $p = .001$ (Tabachneck & Fidell, 2001).

There was not a significant interaction between intervention condition and text type, Wilkes’ $\lambda = .997$, $F(4, 324) = 0.118$, $p = .976$, $\eta^2 = .001$, demonstrating that the effects of the intervention condition were consistent across both text types on strategy use. There was not a significant main effect for text type, Wilkes’ $\lambda = .976$, $F(2, 162) = 1.968$, $p = .143$, $\eta^2 = .024$, indicating no significant difference between participants who read either two separate texts or a single combined text on strategy use. There was a significant main effect of intervention condition, Wilkes’ $\lambda = .818$, $F(4, 324) = 8.573$, $p < .001$, $\eta^2 = .096$. Follow up univariate analyses found significant effects of intervention condition for both ISSI factors: Integration, $F(2, 163) = 9.974$, $p < .001$, $\eta^2 = .109$, Separation, $F(2, 163) = 5.558$, $p = .005$, $\eta^2 = .064$. Post Hoc LSD analysis revealed that participants who received the II intervention had significantly higher scores on the Integration Factor than participants in either the CC ($p < .001$) or CT ($p < .001$) conditions. Furthermore, participants in the II condition had significantly lower scores on the Separation Factor than did participants in either the CC ($p = .015$) or CT ($p = .001$) conditions. Means and standard deviations are reported in Table 4.2 for all six conditions and Table 4.8 for each of the three intervention conditions collapsed across text type on both strategy factors.

Table 4.8

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration Factor</td>
<td>.448 (0.943)</td>
<td>-.205 (0.863)</td>
<td>-.228 (0.901)</td>
</tr>
<tr>
<td>Separation Factor</td>
<td>-.328 (1.055)</td>
<td>.091 (0.809)</td>
<td>.223 (0.803)</td>
</tr>
</tbody>
</table>

Finally, using the Sobel test (Dudley, Benuzill, & Carrico, 2004) the impact of the Integration and Separation factor scores as mediators between intervention condition and each of the independent variables was tested.
Table 4.9  

*Sobel and p values for the test of each ISSI subscale mediation between the intervention and each of the dependent variables*

<table>
<thead>
<tr>
<th>Dependent Measure</th>
<th>Integration Factor</th>
<th>Separation Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sobel</td>
<td>p value</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocrine SVT</td>
<td>0.115</td>
<td>.909</td>
</tr>
<tr>
<td>Urinary SVT</td>
<td>-1.186</td>
<td>.236</td>
</tr>
<tr>
<td>Endocrine PIT</td>
<td>-0.111</td>
<td>.912</td>
</tr>
<tr>
<td>Urinary PIT</td>
<td>-0.464</td>
<td>.643</td>
</tr>
<tr>
<td>Integration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IVT</td>
<td>-0.772</td>
<td>.440</td>
</tr>
<tr>
<td>Verbal FRI</td>
<td>-2.031</td>
<td>.042*</td>
</tr>
<tr>
<td>Drawing FRI</td>
<td>0.086</td>
<td>.931</td>
</tr>
</tbody>
</table>

*Significant at p = .05

For measures of comprehension, Separation significantly mediated the effect of intervention for both the endocrine and urinary PIT measures. The percentage of the total effect that was mediated was -152.22%, and the ratio of indirect to the direct effect was -0.604 for the Separation subscale on the endocrine PIT measure (Sobel = 2.080, p = .038), and the percentage of the total effect that was mediated was 372.25%, and the ratio of indirect to the direct effect was -1.367 for the Separation subscale on the urinary PIT measure (Sobel = 2.240, p = .025). Separation did not significantly mediate the effect of intervention on the two SVT measures, and Integration did not significantly mediate the effect of intervention on any of the comprehension measures (see Table 4.9 for Sobel and p values).

For measures of integration, Integration significantly mediated the effect of intervention condition on the vFRI scores (Sobel = -2.031, p = .042). The percentage of the total effect that was mediated was 26.36%, and the ratio of indirect to the direct effect was 0.358 for the integration subscale on the vFRI measure. Integration did not mediate the effect of intervention on either the IVT or dFRI integration measures. Separation did not mediate the effect of intervention on any measures of integration (see Table 4.9 for Sobel and p values).

This finding supports the hypothesis that the ISSI Integration subscale mediates the effect of the intervention condition on integration scores. The Integration subscale only mediated the effect of intervention on the verbal Free Recall Integration measure, and there was not a mediation effect on any of the measures of comprehension. The analysis was replicated testing the ISSI Separation subscale mediation of the effect of intervention condition on comprehension scores. The Separation subscale mediated the effect of the intervention on
the two measures of large-grain comprehension, but not the measures of small-grain comprehension or any of the measures of integration.

Experiment 3b

Method

Participants.

Participants were 448 (270 female) students recruited during the spring 2013 semester from Biology 240, an introductory biology course taken primarily by biology majors. This is a course that was not used previously. Four participants were removed from analyses for failure to complete all measures (e.g., leaving the study session early). Participants ranged in age from 18 to 39, with participants being 18 (22.5%), 19 (35.9%), 20 (19.2%), or 21 (13.8%); few participants were 22 and over (8.4%). The majority of participants identified as White (73.7%), with the remaining participants identifying as American Indian (0.2%), Asian (12.5%), Black (4.9%), Pacific Islander (1.1%), and Hispanic (4.2%). Several participants indicated “other” (2.5%) or did not respond (0.7%). Participants represented a range of semester standing; freshman (0 – 1 semesters completed; 43.8%), sophomore (2 – 3 semesters completed; 29.7%), junior (4 – 5 semesters completed; 12.5%), senior (6 – 7 semesters completed; 12.1%), and greater (8 – 16 semesters completed; 2.0%). Self-reported grade point average (GPA) ranged from 1.5 to 4.3 with the mean GPA of 3.25 (SD = 0.46). Of the 414 participants who reported a valid Verbal SAT score, the mean was 610.2 (SD = 80.9). Most participants reported English as their first language (89.7%). Nearly two-thirds of the participants (64.5%) reported being in a biology-related major, compared to Experiment 3a, where only 33.8% were enrolled in a biology-related major. [See Appendix C for a copy of the Implied Consent Document used in Experiment 3b.]
Design.

There were no changes to the design from Experiment 3a to Experiment 3b. Participants were randomly assigned to one of six conditions in a 3 (intervention condition) x 2 (text type) experimental design. The three intervention conditions were: inspiring integration (II), coaching comprehension (CC), control task (CT). The two text types were: two separate texts (S) and a combined text (C). Thus, the six conditions were identical to those employed in Experiment 3a. Dependent measures assessed comprehension and integration via the same measures used in Experiment 2. All participants also completed three individual difference measures: biology prior knowledge, Need for Cognition (NFC), and ISSI.

Materials.

Individual Difference Measures.

Demographics. The demographic survey included questions on age, gender, race, semesters completed, grade point average, current major, verbal SAT score and first language. This measure is unchanged from Experiment 3a.

Biology prior knowledge. The 10-item biology prior knowledge measure was the same as that used in Experiment 3a ($\alpha = .292$).

Need for Cognition. The 18-item Need for Cognition (NFC) measure was the same as that used in Experiment 3a ($\alpha = .864$).
Knowledge measures

Single-text comprehension.

Small-grain text comprehension: Sentence verification technique. The SVT measures were unchanged from Experiment 3a. The reliability of scores was not improved from Experiment 3a, internal consistency for the 16-item measures was still rather low\(^1\): the endocrine system, \(\alpha = .386\), and the urinary system, \(\alpha = .360\).

Large-grain text comprehension: Principle identification technique. The items from the PIT measures were unchanged from Experiment 3a. The reliability of scores was not improved from Experiment 3a, internal consistency for the 4-item measures was still rather low\(^1\): the endocrine system, \(\alpha = .199\), and the urinary system, \(\alpha = .340\).

Integration measures.

Small-grain integration: Inference verification technique. The IVT measure was unchanged from Experiment 3a. The reliability of scores was not improved from Experiment 3a, internal consistency was unacceptably low\(^1\), \(\alpha = .085\).

Large-grain integration: Free recall.

Verbal free recall integration. The verbal free recall integration measure (vFRI) was unchanged from Experiment 3a. The responses were coded into the same 4-point rubric measuring large-grain integration. Inter-rater agreement was established on 20% of the participants’ responses; the two raters achieved 85% agreement. Two raters each independently coded 50% of the remaining responses.

Drawing free recall integration. The drawing free recall integration (dFRI) measure was unchanged from Experiment 3a. The responses were coded into the 4-point rubric measuring large-grain integration. Inter-rater agreement was established on 20% of the participants’ responses; the two raters achieved 91% agreement. Two raters each independently coded 50% of the remaining responses.

Integration and Separation Strategy Inventory (ISSI). The ISSI is a measure of self-reported strategy use adapted from the Multiple-Text Strategy Inventory (MTSI; Bråten & Strømsø, 2010). The ISSI was unchanged from Experiment 3a. The values for the two subscales were derived from factor scores. As a replication of Experiment 3a,
three items were removed; the Integration Factor was comprised of seven items, \( \alpha = .850 \), and the Separation Factor was comprised of six items, \( \alpha = .759 \). More information regarding the EFA is reported in the Results section.

*Open-ended comments (optional).*

An optional open-ended response measure was included. This prompt was identical to that used in Experiment 3a.

*Independent variables.*

*Experimental texts.*

The experimental texts were unchanged from Experiment 3a.

*Intervention conditions.*

The intervention conditions were unchanged from Experiment 3a.

*Procedures.*

Students in Biology 240 were informed that participation in the study was voluntary and that they would receive extra-credit in their biology course for participation. Students earned extra points toward their final grade. While clicker questions were not a component of Experiment 3b, students were informed that the content used in the experiment corresponded to content that would be covered in upcoming lectures and would be included on the final exam.
Students signed up for experimental sessions through an online sign-up system. Twelve experimental sessions were offered at various times over the course of eight academic days in reserved computer labs on campus. Sessions were reserved for two-hour slots, with at least 30 minutes between each session. All participants started at the same time for each session. Computer labs ranged from 30 to 80 computers per lab. The author ran all sessions. All other procedures are the same for Experiment 3a.

Results

Preliminary analysis.

Descriptive statistics are presented in Table 4.10. For each of the six conditions, means and standard deviations are provided for both individual difference and dependent measures.
Table 4.10

Master table of means and standard deviations for each of the six conditions

<table>
<thead>
<tr>
<th></th>
<th>Inspiring Integration</th>
<th>Coaching Comprehension</th>
<th>Control Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Combined (n=76)</td>
<td>Separate (n=76)</td>
<td>Combined (n=75)</td>
</tr>
<tr>
<td>Individual difference measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPK</td>
<td>5.89 (1.59)</td>
<td>5.87 (1.49)</td>
<td>6.09 (1.55)</td>
</tr>
<tr>
<td>NFC</td>
<td>11.30 (18.63)</td>
<td>12.01 (17.83)</td>
<td>10.11 (15.29)</td>
</tr>
<tr>
<td>ISSI - Integration</td>
<td>0.54 (0.78)</td>
<td>0.52 (0.78)</td>
<td>-0.20 (0.89)</td>
</tr>
<tr>
<td>ISSI - Separation</td>
<td>-0.14 (0.86)</td>
<td>-0.23 (0.89)</td>
<td>0.08 (0.90)</td>
</tr>
<tr>
<td>Dependent measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVT End.</td>
<td>9.99 (2.33)</td>
<td>10.91 (2.31)</td>
<td>10.57 (2.39)</td>
</tr>
<tr>
<td>SVT Uri.</td>
<td>10.47 (2.06)</td>
<td>10.63 (2.17)</td>
<td>10.67 (2.10)</td>
</tr>
<tr>
<td>PIT End.</td>
<td>25.16 (5.32)</td>
<td>26.19 (5.31)</td>
<td>26.91 (4.38)</td>
</tr>
<tr>
<td>PIT Uri.</td>
<td>27.13 (5.29)</td>
<td>28.16 (4.66)</td>
<td>27.78 (4.70)</td>
</tr>
<tr>
<td>IVT</td>
<td>9.33 (1.84)</td>
<td>9.33 (1.94)</td>
<td>9.08 (1.96)</td>
</tr>
<tr>
<td>vFRI</td>
<td>2.00 (0.94)</td>
<td>1.86 (0.96)</td>
<td>1.47 (0.70)</td>
</tr>
<tr>
<td>dFRI</td>
<td>1.63 (0.76)</td>
<td>1.49 (0.77)</td>
<td>1.69 (0.66)</td>
</tr>
</tbody>
</table>
Time. Qualtrics recorded time spent on the condition specific instructions as well as the text(s). For each of these, time range varied widely, and the distributions were positively skewed. Time spent on the instructions ranged from 1.6 seconds to 87.1 seconds. These times were compared across conditions to test the possibility that there is a condition effect on time-on-task. Statistical outliers were removed using the outlier labeling rule with $g = 2.2$ (Hoaglin & Iglewicz, 1987). These outliers are removed for the time analyses reported here but were retained for all subsequent analyses involving learning and individual difference variables. Figure 4.13 shows the histogram of time distributions on the instructions by intervention condition.

![Time Spent on Instructions by Condition](image)

*Figure 4.13 Time spent on instructions per intervention condition.*

For participants who read separate texts, time on the endocrine system text ranged from 3.0 seconds to 40.9 minutes, and time ranged from 2.1 seconds to 41.5 minutes for urinary system text. For participants who read a combined text, time ranged from 12.0 seconds to 68.5 minutes. Figure 4.14 compares the time spent for each of the two separate texts; Figure 4.15 shows the time spent on the combined text.
Figure 4.14. Time spent on the endocrine text and the urinary text for participants in the separate texts condition.

Figure 4.15. Time spent on the text for participants in the single combined text condition.
Four statistical outliers were identified on the instructions, one in the II condition, and three in the CC condition. Table 4.11 contains the means and standard deviations for time spent on the instructions for each of the intervention conditions after removal of the outliers. A one-way ANOVA tested the differences in time spent on the instructions for each of the three intervention conditions. There was a significant difference between the times spent on the instructions for the three different interventions, $F(2, 441) = 10.712, p < .001$. Post Hoc LSD analysis revealed that participants in the II intervention condition spent significantly longer on the instructions than participants in both the CC intervention ($p < .001$) and the CT ($p < .006$). Compared to Experiment 3a, participants spent a similar amount of time reading the instructions (14 – 16 seconds).

Table 4.11

**Time spent by intervention condition on the instructions and text**

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions in seconds</td>
<td>17.38 (9.38)</td>
<td>13.25 (6.30)</td>
<td>14.93 (7.00)</td>
</tr>
<tr>
<td>Separate Texts in minutes</td>
<td>23.30 (13.13)</td>
<td>16.28 (15.36)</td>
<td>29.41 (17.84)</td>
</tr>
<tr>
<td>Combined Text in minutes</td>
<td>15.54 (11.84)</td>
<td>18.30 (15.90)</td>
<td>26.19 (15.13)</td>
</tr>
</tbody>
</table>

There were no outliers for time spent on the text(s). See Table 4.11 for the means and standard deviations for time spent on the text(s) for each of the three intervention conditions. A 2 (text type) x 3 (intervention condition) ANOVA tested the differences on total time spent on the text(s). There was a significant interaction between text type and intervention condition, $F(2, 442) = 3.95, p = .020$. See Figure 4.16 for a depiction of the disordinal interaction of intervention condition by text type. Because the interaction was disordinal, main effects could not be interpreted. The analysis was followed by a test of simple effects. There was a significant difference of condition for participants who read two separate texts, $F(2, 219) = 12.959, p < .001$, even after adjusting the alpha for multiple tests. Post Hoc LSD analysis revealed that participants in the CT condition spent significantly longer reading the two separate texts than participants in either the II ($p = .016$) or CC ($p < .001$) conditions. In addition, participants in the II condition spent significantly longer reading the two separate texts than did participants in the CC condition ($p = .007$). There was also a significant difference of condition for participants who read a single combined text, $F(2, 223) = 11.113, p < .001$. Post Hoc LSD analysis revealed that participants in the CT condition spent significantly longer reading the single text than participants in either the II ($p < .001$) or CC ($p = .001$) conditions. There was not a significant difference in the time spent reading the combined for participants in the II condition compared to those
in the CC condition. Additionally, there was a significant difference between text types for participants in the II condition, $F(1, 150) = 14.625, p < .001$, even after adjusting the alpha for multiple tests. Participants in the II – C condition spent significantly longer reading than participants in the II – S condition. There was not a significant difference between text types for participants in the CC condition, $F(1, 143) = 0.602, p = .439$, or the control task, $F(1, 149) = 1.430, p = .234$.

![Time Spent Reading the Text(s) per Condition](image)

*Figure 4.16* Bar graph of the interaction between intervention condition and text type on time spent reading the text(s).

**Effect of intervention condition on comprehension.**

*Small-grain comprehension.*

A 2 (text type) X 3 (intervention condition) MANOVA assessed the impact of text type and intervention condition on the two SVT scores. Biology prior knowledge was tested for use as a covariate. The correlation between biology prior knowledge and SVT measures was significant for both dependent measures, $r = .229$ (endocrine SVT), $r = .258$ (urinary SVT), but homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and a significant interaction was found. As such, a covariate
was not used in the analyses. Levine’s homogeneity of variance was not significant, \( p = .520 \) (endocrine) and \( p = .338 \) (urinary), suggesting the variances for both dependent variables were equal. Box’s M was not significant, \( p = .092 \), indicating the covariance matrices of the dependent variables are equal across groups, and as a result, Wilkes’ \( \lambda \) was interpreted.

The text type by intervention condition interaction was non-significant, Wilkes’ \( \lambda = .980 \), \( F(4, 822) = 2.210, p = .066, \eta^2 = .010 \), demonstrating that the effects of the intervention condition on comprehension scores were consistent across both text types. There was not a significant main effect for text type, Wilkes’ \( \lambda = .987 \), \( F(2, 441) = 2.84, p = .059, \eta^2 = .013 \), demonstrating that there was no significant difference between participants who read either two separate texts or a single combined text on the SVT small-grain comprehension measures. There was, however, a significant main effect of intervention condition, Wilkes’ \( \lambda = .960 \), \( F(4, 882) = 4.496, p = .001 \), \( \eta^2 = .020 \).

Univariate analyses for intervention condition resulted in significant differences on only the endocrine system SVT measure, \( F(2, 442) = 9.071, p < .001, \eta^2 = .039 \). There were no significant differences for intervention condition on the urinary SVT measure, \( F(2, 442) = 1.771, p = .171, \eta^2 = .008 \). Post Hoc LSD analysis on the endocrine system SVT measure revealed that participants in the CT condition scored significantly higher than participants in either the II (\( p < .001 \)) or CC (\( p = .007 \)) conditions. This pattern indicates that participants in the CT condition had a comprehension advantage over participants in the II and CC conditions. See Table 4.10 for the SVT means and standard deviations for each of the six conditions, and Table 4.12 for the SVT means and standard deviations for each of three interventions collapsed across text type.

Table 4.12

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVT Endocrine</td>
<td>10.45 (2.36)</td>
<td>10.81 (2.22)</td>
<td>11.52 (2.11)</td>
</tr>
<tr>
<td>SVT Urinary</td>
<td>10.55 (2.11)</td>
<td>10.73 (2.04)</td>
<td>11.02 (2.35)</td>
</tr>
</tbody>
</table>

The results of Experiment 3b are consistent with the trends obtained in Experiment 3a. In both cases, participants in the CT condition had higher mean scores on the SVT measures in comparison to the other intervention conditions. In Experiment 3b, however, the differences were stronger and resulted in finding a statistical significant effect of condition on the endocrine SVT measure. Taken together, these two experiments
indicate that there is no text comprehension advantage for participants provided with support specific to text comprehension. Instead, it seems that participants who completed the control note-taking had the strongest advantage on these small-grain comprehension measures.

**Large-grain comprehension.**

A 2 (text type) x 3 (intervention condition) MANCOVA with biology prior knowledge as the covariate assessed the impact of intervention and text type on the two PIT scores. All assumptions were assessed and met. Biology prior knowledge was tested for, and used, as a covariate. The correlation between biology prior knowledge and IVT measures were significant for both dependent measures, $r = .148$ (endocrine PIT), $r = .133$ (urinary PIT). Homogeneity of regression assessed the interaction between the independent variables and biology prior knowledge, and no significant interaction was found. Levine’s homogeneity of variance was significant for the endocrine PIT measure, $p = .046$ but not for the urinary PIT measure, $p = .073$, suggesting the error variance for the urinary PIT measure is equal across groups, but the error variance of the endocrine PIT measure was not. Due to the sample size, MANOVA is robust to violations of homogeneity of variance. Box’s M was not significant, $p = .131$, indicating the covariance matrices of the dependent variable are equal across groups, and as a result, Wilkes’ $\lambda$ was interpreted.

There was no significant interaction between text type and intervention condition, Wilkes’ $\lambda = .993$, $F(4, 880) = .790, p = .531, \eta^2 = .004$, indicating that the effects of intervention condition were consistent across both text types on comprehension. There was no significant main effect of intervention condition, Wilkes’ $\lambda = .988$, $F(4, 880) = 1.381, p = .239, \eta^2 = .006$ indicating that participants who were given the CC intervention did not score significantly higher than participants in the CT or the II conditions on large-grain comprehension measures. There was no significant effect of text type, Wilkes’ $\lambda = 1.000$, $F(2, 440) = 0.029, p = .972, \eta^2 = .000$, demonstrating that participants who read either two separate texts or a single combined text did not perform significantly different on the large-grain comprehension measure. See Table 4.10 for the PIT means and standard deviations for each of the six conditions, and Table 4.13 for the PIT means and standard deviations for each of three interventions collapsed across text type.
Table 4.13

Means and standard deviations for each of the interventions collapsed across text type for both PIT measures of comprehension

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIT Endocrine</td>
<td>25.67 (5.32)</td>
<td>26.97 (4.82)</td>
<td>26.35 (5.49)</td>
</tr>
<tr>
<td>PIT Urinary</td>
<td>27.64 (5.00)</td>
<td>27.67 (5.08)</td>
<td>27.44 (5.56)</td>
</tr>
</tbody>
</table>

These findings align with Experiment 3a, and indicate that providing college students with an intervention that targets large-grain comprehension does not improve comprehension scores relative to participants who receive either an II or CT condition. Additionally, it is noted that providing students with an II intervention does not harm large-grain comprehension compared to participants who were instructed to focus on a comprehension or control task.

**Effects of intervention condition on integration.**

**Small-grain integration.**

An ANCOVA, with biology prior knowledge as the covariate, assessed the impact of text type and intervention condition on the IVT measure of multiple-text integration. All assumptions were assessed and met. The correlation between biology prior knowledge and the IVT measure was significant, $r = .129$, permitting the use of this covariate. Homogeneity of regression assessed the interaction between the independent variable and biology prior knowledge, and no significant interaction was found. Levine’s homogeneity of variance was not significant, $p = .811$, indicating equality of variances for the IVT variable.

There was not a significant interaction between text type and intervention condition, $F(2, 441) = 0.183, p = .832, \eta^2 = .001$, indicating that the effects of the intervention condition were consistent across both forms of text type. There was not a significant effect of text type, $F(1, 441) = 0.173, p = .678, \eta^2 = .000$, indicating that there was not a significant difference between participants who read either a single combined or two separate texts on the IVT measure. There was also not a significant effect of intervention condition, $F(2, 441) = 0.895, p = .409, \eta^2 = .004$, indicating that there was not a significant difference between participants in the inspiring integration intervention,
coaching comprehension intervention, or the control task on the IVT integration measure. See Table 4.10 for the IVT means and standard deviations for each of the six conditions, and Table 4.14 for the IVT means and standard deviations for each of three interventions collapsed across text type.

Table 4.14

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVT</td>
<td>9.32 (1.89)</td>
<td>9.10 (2.03)</td>
<td>9.09 (1.89)</td>
</tr>
</tbody>
</table>

These findings replicate the findings from Experiment 3a, and together they suggest that providing students with an II intervention was not sufficient to impact their integration as measured by the IVT measure, compared to participants who received the CC or CT intervention conditions. There is no evidence to support the hypothesis that participants who received integration support scored higher on the measure of integration than those who were not given integration support nor was there evidence to support the hypothesis that participants who read a combined text scored higher on the measure of integration than those who read two separate texts. Furthermore, there was not an interaction between intervention and text type. Also consistent with Experiment 3a, the reliability of scores from the IVT are poor and thus, the interpretation of these results is guarded.

Large-grain integration

A 2 (text type) x 3 (intervention condition) MANOVA tested the impact of text type and intervention condition on the two free recall measures of large-grain integration. The biology prior knowledge measure was not used as a covariate, because it did not meet the requirements. Levine’s homogeneity of variance was significant for one measure \( p < .001 \) (vFRI) but not the other \( p = .100 \) (dFRI), suggesting the error variance for the drawing free recall integration measure is equal across groups, but the error variance of the verbal free recall integration measure is not. Box’s M was significant, \( p < .001 \), indicating the covariance matrices of the dependent variables were not equal across groups, and as a result, Wilkes’ \( \lambda \) was interpreted. While MANOVA is robust to violations with large sample sizes, when the probability of significant differences in Box’s M is less than .001, extreme caution should be used when interpreting the results (Tabachneck & Fidell, 2001). For this reason, the pattern of findings from the
parametric MANOVA was confirmed with a follow-up nonparametric Chi Square analysis. While only the results from the parametric MANOVA are reported below, the results pertaining to the Chi Square analysis were consistent with the MANOVA, thus alleviating some concern due violation of the assumption of equality of covariance matrices.

There was no significant interaction between text type and intervention condition, Wilkes’ $\lambda = .994$, $F(4, 882) = 0.616, p = .651, \eta^2 = .003$, indicating that the effects of the intervention condition were consistent across both text types. There was, however, a significant effect of text type, Wilkes’ $\lambda = .975$, $F(2, 441) = 7.862, p = .003, \eta^2 = .025$, indicating that participants who read a single combined text had higher integration scores on the free recall integration measures than participants who read two separate texts. Univariate analyses for text type resulted in significant differences only on the verbal free recall integration measure, $F(1, 442) = 9.936, p = .002, \eta^2 = .022$, but not the drawing free recall integration measure, $F(1, 442) = 2.333, p = .127, \eta^2 = .005$.

There was also a significant effect of intervention condition, Wilkes’ $\lambda = .870$, $F(4, 882) = 15.837, p < .001, \eta^2 = .067$, indicating that there was a significant difference between participants given the different intervention conditions on the free recall integration measures. Univariate analyses for intervention condition again resulted in significant differences on the verbal free recall integration measure, $F(2, 442) = 30.956, p < .001, \eta^2 = .123$, but not the drawing free recall integration measure, $F(1, 442) = 1.562, p = .211, \eta^2 = .007$. Post Hoc LSD analyses of the vFRI measure revealed that participants in the II intervention condition scored significantly higher than participants in either the CC ($p < .001$) or the CT ($p < .001$) conditions. See Table 4.10 for the FRI means and standard deviations for each of the six conditions, and Table 4.15 for the FRI means and standard deviations for each of three interventions collapsed across text type.

Table 4.15

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>vFRI</td>
<td>1.93 (0.95)</td>
<td>1.39 (0.66)</td>
<td>1.32 (0.57)</td>
</tr>
<tr>
<td>dFRI</td>
<td>1.56 (0.78)</td>
<td>1.63 (0.65)</td>
<td>1.49 (0.64)</td>
</tr>
</tbody>
</table>

This finding replicates the findings from Experiment 3a, and supports the hypothesis that participants who received an integration intervention would score higher on an assessment of integrated knowledge than would participants who did not receive this intervention. The lack of an intervention by text type interaction indicates that
the II intervention supported integration of these biological systems even when the to-be-connected concepts were presented in separate texts. Furthermore, the significant difference between scores of participants in the II and CC conditions indicates that integration of systems requires more than mere comprehension of the individual systems.

**Effects of intervention condition on strategy use.**

**Integration and Separation Strategy Inventory (ISSI).**

Exploratory factor analysis tested the viability of the two factor solution derived from the final EFA from Experiment 3a. Accordingly, a maximum likelihood exploratory factor analysis was performed for all 448 participants on the 13 ISSI items retained in Experiment 3a. Oblique rotation (promax) was chosen to account for an expected correlation between subscales. Missing values were replaced with the mean. The factor analysis was restricted to two factors; these two factors accounted for 45.8% of the variance. All items loaded onto the same factor as Experiment 3a, and confirmed the a priori expectations. The factor scores were identified as Integration and Separation, and saved using the regression method. Accordingly, Cronbach’s alpha reliability values reported in the methods section were conducted including the seven integration items that loaded onto the Integration Factor and the six separation items that loaded onto the Separation Factor. See Appendix C for the factor loadings of each item onto the respective factors for Experiment 3b.

A 2 (text type) X 3 (intervention condition) MANOVA assessed whether there were any differences between conditions on the two scale scores. Text type and intervention condition were entered as independent variables. Scores on the Integration and Separation subscales served as the dependent variables. Biology prior knowledge was not used as a covariate because it did not meet the assumptions. Levine’s homogeneity of variance was not significant, $p = .208$ (Integration) and $p = .439$ (Separation), suggesting the variances for both dependent variables were equal. Box’s M was not significant, $p = .489$, indicating the covariance matrices of the dependent variable were equal across groups, Wilkes’ $\lambda$ was interpreted.

There was not a significant interaction between intervention condition and text type, Wilkes’ $\lambda = .986$, $F(4, 884) = 1.614$, $p = .169$, $\eta^2 = .007$, demonstrating that the effects of the intervention condition were consistent across
both text types on strategy use. There was not a significant main effect for text type, Wilkes’ $\lambda = .993$, $F(2, 441) = 1.548, p = .214, \eta^2 = .007$, indicating no significant difference between participants who read either two separate texts or a single combined text on strategy use.

The main effect of intervention condition was significant, Wilkes’ $\lambda = .833$, $F(4, 884) = 8.573, p < .001, \eta^2 = .087$. Follow-up univariate analyses found significant differences on the intervention condition for both factors; Integration, $F(2, 442) = 42.284, p < .001, \eta^2 = .161$, Separation, $F(2, 442) = 5.374, p = .005, \eta^2 = .024$. LSD post hoc analysis revealed that participants in the II condition had significantly higher scores on the Integration Factor than participants in either the CC ($p < .001$) or CT ($p < .001$) conditions. Furthermore, participants in the II condition also had significantly lower scores on the Separation Factor than did participants in either the CC ($p = .013$) or CT ($p = .002$) conditions. Means and standard deviations are reported in Table 4.10 for all six conditions and Table 4.16 for each of the three intervention conditions collapsed across text type on both strategy factors.

Table 4.16

Means and standard deviations for ISSI subscales for each of the intervention conditions

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>CC</th>
<th>CT</th>
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<tbody>
<tr>
<td>Integration Factor</td>
<td>.528 (.787)</td>
<td>-.214 (.937)</td>
<td>-.326 (.911)</td>
</tr>
<tr>
<td>Separation Factor</td>
<td>-.186 (.875)</td>
<td>.066 (.826)</td>
<td>.124 (.916)</td>
</tr>
</tbody>
</table>

Finally, using the Sobel test (Dudley et al., 2004) the impact of Integration and Separation as mediators between intervention condition and each of the independent variables was tested.

Table 4.17

Sobel and $p$ values for the test of each ISSI subscale mediation of the intervention and each of the dependent variables

<table>
<thead>
<tr>
<th>Dependent Measure</th>
<th>Integration Factor</th>
<th>Separation Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endocrine SVT</td>
<td>1.121, $p = .262$</td>
<td>2.006, $p = .045^*$</td>
</tr>
<tr>
<td>Urinary SVT</td>
<td>1.479, $p = .139$</td>
<td>2.486, $p = .013^*$</td>
</tr>
<tr>
<td>Endocrine PIT</td>
<td>0.722, $p = .470$</td>
<td>2.691, $p = .007^*$</td>
</tr>
<tr>
<td>Urinary PIT</td>
<td>-0.587, $p = .557$</td>
<td>2.540, $p = .011^*$</td>
</tr>
<tr>
<td>IVT</td>
<td>0.218, $p = .827$</td>
<td>0.500, $p = .617$</td>
</tr>
<tr>
<td>Verbal FRI</td>
<td>-3.924, &lt; .001*</td>
<td>-1.238, $p = .216$</td>
</tr>
<tr>
<td>Drawing FRI</td>
<td>-0.220, $p = .826$</td>
<td>-0.570, $p = .569$</td>
</tr>
</tbody>
</table>

*Significant at $p = .05$
For measures of comprehension, Separation significantly mediated the effect of intervention on all four measures of comprehension. For the endocrine SVT measure, the percentage of the total effect that was mediated was 9.19%, and the ratio of indirect to the direct effect was .101. For the urinary SVT measure, the percentage of the total effect that was mediated was 32.06%, and the ratio of indirect to the direct effect was .472. For the endocrine PIT measure, the percentage of the total effect that was mediated was 49.69%, and the ratio of indirect to the direct effect was .988. For the urinary PIT measure, the percentage of the total effect that was mediated was -189.945%, and the ratio of indirect to the direct effect was -.655. Integration did not mediate the effect of intervention on any measures of comprehension (See Table 4.17 for Sobel and p values).

For measures of integration, Integration significantly mediated the effect of intervention condition on the vFRI scores (Sobel = -2.031, p = .042). The percentage of the total effect that was mediated was 24.39% and the ratio of indirect to the direct effect was .323 for the integration subscale on the vFRI measure. Integration did not mediate the effect of intervention on either the IVT or dFRI integration measures. Separation did not mediate the effect of intervention on any measures of integration (See Table 4.17 for Sobel and p values).

This finding supports the hypothesis that the ISSI Integration subscale mediates the effect of the intervention condition on integration scores. The Integration subscale only mediated the effect of intervention on the vFRI integration measure, and there was not a mediation effect on any of the measures of comprehension. The analysis was replicated testing the ISSI Separation subscale mediation of the effect of intervention condition on comprehension scores. The Separation subscale mediated the effect of the intervention on all four measures of comprehension, but none of the measures of integration. The pattern of results is consistent with Experiment 3a.

**Conclusion**

Experiment 3 tested an intervention specifically developed to enhance participants’ integration. The intervention, inspired by the SOAR strategy (Kiewra, 2005; 2009), provided participants with three different aspects targeted to help them: (1) select and organize relevant information about the endocrine and urinary system, (2) associate relevant information between the systems, and (3) regulate toward the goal of integration. This intervention, *inspiring integration*, used the integration instructions and understanding supports delivered as part of
Experiments 1 and 2, but enhanced them. This integration intervention was compared to an intervention designed to support comprehension (i.e., coaching comprehension) and a control (i.e., control task). As in Experiment 2, half of the participants read a single text, and half of the participants read two separate texts. The same dependent measures from Experiment 2, along with a new measure of self-reported strategy use, were collected.

Participants were recruited from two different courses. In Experiment 3a, participants were recruited from a class similar to Experiments 1 and 2 and were provided with additional incentive to study from the materials. Participants in Experiment 3b were recruited from a class with a larger proportion of students enrolled in biology-related majors. On average, participants in Experiment 3b scored one point higher on the biology prior knowledge measure than participants in 3a. Because of these differences, and because participants in 3a had additional motivation to study the materials, the two populations were not combined. Thus, Experiment 3b served as a replication of Experiment 3a.

In both Experiment 3a and 3b, participants spent nearly twice as long reading the materials than in Experiment 2. This increase in time may be due to greater investment of participants. But a deeper look at the times associated with each condition, showed that the time spent reading the texts varied significantly by condition for both experiments. Participants who completed the control task actually spent significantly longer reading the text(s) and completing the intervention than participants in the II and CC conditions.

In Experiment 3a, for one of the small-grain measures of comprehension, there was a trend for participants in the CT condition to have higher scores than participants in either intervention conditions. In Experiment 3b, these differences were statistically significant. Yet on integration measures in both Experiments 3a and 3b, participants in the II condition scored significantly better than those in the CT and CC conditions. This combination of findings indicates that just spending more time on the task or having better single-text comprehension does not result improved integration.

The differences on the integration measure in both Experiments 3a and 3b indicate that the effect of the II intervention was able to enhance students’ integration between two biology systems. The replication of this effect across two experiments strengthens confidence that the II intervention provides the necessary support for readers to
integrate. Additionally, in both Experiment 3 studies, participants who read a single combined text scored higher on a large-grain integration measure than participants who read two separate texts.

In Experiment 3, participants completed a self-report measure of strategy use (ISSI). The measure produced two factors, Integration and Separation. Participants in the II condition scored significantly higher on the Integration factor than participants in either the CC or CT conditions. These findings indicate that participants who completed an intervention task intended to stimulate integration did indeed report engaging in the use of integration strategies more frequently. Additionally, participants in the II condition scored lower than participants in either the CC or CT conditions on the Separation factor. Recognizing the strength of the impact of intervention on the self-report strategy use, the two factors produced by the ISSI were tested for mediation on the dependent variables. Across both experiments, the pattern of results was striking. The Separation Factor mediated between the intervention condition and most of the dependent measures associated with comprehension (i.e., SVT and PIT measures), while the Integration Factor mediated between the intervention condition and one of the dependent measures associated with integration (i.e., vFRI measure).
Chapter 5

Discussion

This dissertation study consists of three related experiments. Each experiment contributed to understanding what is required to promote the integration of multiple biology texts for college student readers. The discussion presented here provides a summary of the results from Experiments 1, 2, 3a, and 3b. The results from these experiments are considered within the broader literature base. Additionally, the limitations of these experiments will be considered along with directions for future research.

Summary of the Experiments

Review of the problem.

In many human anatomy and physiology courses, students are taught the main systems of the body in discrete units (e.g., Saladin, 2010). Although the content is delivered in isolated chapters, the body systems covered in these chapters are highly interrelated, and thus, high quality understanding of human anatomy and physiology requires that students draw connections across these readings. This phenomenon can be illustrated with the endocrine and urinary systems. The endocrine system is responsible for secreting hormones. Two particular hormones secreted by this system, antidiuretic hormone and aldosterone, have a direct effect on the kidneys of the urinary system. When these hormones travel through the blood and target the kidneys, water absorption is increased. As a result of increased water absorption, blood volume is increased. This increase in blood volume also increases blood pressure, which in turn, affects the circulatory system. In this example alone, the endocrine system has an impact on at least two other body systems. Yet, students who study this content in isolation often overlook the connections between these systems.
Experts argue, however, that a deep understanding of biology requires an understanding of how these systems are connected (AAAS, 2011). Educational research can facilitate the development of interventions that help learners to integrate multiple texts. If students’ connections between systems can be supported, then it will be possible to support their understanding of how body systems operate together and function as a whole.

**Brief review of the experiments.**

The purpose of this research has been the development of an intervention that facilitates the generation of connections between biology systems for students enrolled in early biology courses. The goal of the research was to develop a minimally invasive intervention – one that required little-to-no demand on course instructors – yet one that produced effective results. In order to achieve this goal, a set of three sequential studies was conducted with each study building upon the findings of the former. Although Experiments 1 and 2 demonstrated that students require more than instructions to integrate texts, the intervention tested in the third experiment shows promise as a method for prompting and supporting college students’ integration across texts. The main research question of Experiment 1 was, “Can students integrate two biology systems if they know that this content should be integrated?” In this study, college students were given a set of instructions prior to reading two biology texts. Half of the participants were given instructions that explicitly directed them to integrate the two texts, while the other half were given instructions only to read two texts. Results from Experiment 1 provided no evidence that knowing texts should be integrated is sufficient for integration to occur. Students given instructions to integrate did not score higher on measures of text integration than did participants who were told only to read to comprehend.

One potential explanation for why participants in Experiment 1 did not integrate the texts was because they did not understand the meaning of the instructions to integrate. Thus, Experiment 2 tested the hypothesis that ensuring students understand the integration instructions would increase the tendency to generate connections between the systems. Specifically, this experiment took the ‘know’ hypothesis one step further by asking, “Can students successfully integrate biology content if they both know that they should integrate and they understand what integration means?” Although knowing and understanding that one should integrate may be necessary for students to build connections between multiple texts, the results of Experiment 2 indicate that these conditions are
not sufficient for integration to occur. Students given instructions to integrate with additional support to ensure they understood did not score higher on measures of text integration than did participants who were told only to read to integrate or to read to comprehend.

Experiment 3 tested the effect of an intervention, which was designed to enhance the support provided to participants given instructions to integrate. This experiment tested the hypothesis that an intervention would be both necessary and sufficient to increase students’ generation of integration between two biology systems. In this experiment, participants were assigned to one of three conditions, inspiring integration (II), coaching comprehension (CC) or a control task (CT). Experiment 3 asked, “Can students successfully integrate biology content if an intervention provides them the necessary support to accomplish integration?” The results of Experiments 3a and 3b indicated that the experimental intervention effectively increased text integration. Participants who received the inspiring integration intervention scored higher on a measure of text integration than did participants who were given an intervention designed to enhance comprehension and participants who were given a control task. Furthermore, the results of the ISSI indicate that the intervention was effective because it increased students’ tendency to use integration strategies.

The section below summarizes the findings from these three experiments.

**Summary of findings.**

As described above, two conditions were included in Experiment 1. In one condition, participants were told to integrate two texts. Participants in the second condition were told to comprehend two texts. The main hypothesis tested in this experiment was that students who were informed about the importance of generating connections between two texts would score higher on posttest measures sensitive to this integration. There were no differences on a posttest measure of integration between participants who received instructions to integrate compared to participants who received only instructions to comprehend. Moreover, there was not a difference between the two conditions on either measure of single-text comprehension.

Although the results of Experiment 1 point to a conclusion that knowing the texts should be integrated is not sufficient for integration to occur, there are two alternative explanations that should also be considered. First,
students may not have actually attended to the experimental instructions. The average time spent reading the instructions was just over twelve seconds; 65 of the 318 participants spent less than five seconds reading the instructions page. Not only does the time on instructions suggest students did not attend to experimental instructions, but also participants’ failure to correctly restate the instructions. Specifically, immediately following the experimental instructions, all participants in this experiment were requested to, “repeat the instructions you were just given and describe them with as much detail as possible”. Only 68% of the participants were able to successfully report the delivered instructions. While the majority of participants who received instruction to comprehend were able to respond correctly (i.e., 82%), only 53% of the participants told to integrate were able to recall the instructions. In addition to the limited attention given to experimental instructions, students spent little time (i.e., five minutes on average) reading each instructional text. Ultimately, however, even when students who did not accurately recall the instructions were removed from the analyses, there was no evidence that experimental participants had integrated the texts. Thus, while efforts to enhance attention to integration instructions are certainly necessary for follow-up research, the results of Experiment 1 indicate that more extensive support is necessary for readers to achieve the goal of multiple-text integration.

A second alternative explanation for the findings of the no instructions effect in Experiment 1 is that the measure of integration was not sensitive enough to detect differences between the two conditions. Scores derived from the IVT test, used to measure integration, had poor reliability. Because there was only one measure of integration, it is unclear whether the failure to detect differences was due to the scores of the measure or the instructions that were delivered. This concern is lessened after inspection of the confidence intervals and low effect sizes. Furthermore, Need for Cognition significantly predicted performance on this measure after accounting for comprehension of the texts. That is, although the IVT contained a significant amount of error variance, the NFC measure was still sensitive enough to detect differences related to students’ tendency to “engage in and enjoy effortful cognitive activities” (Petty, Brinol, Loersch, & McCaslin, 2009, p. 318). Nonetheless, the need to revise the IVT and incorporate a new measure of integration was clear from the findings of Experiment 1.

Experiment 2 was designed to rule out these alternative explanations from Experiment 1, as well as to extend the conditions for supporting integration. The first alternative explanation from Experiment 1, that students did not attend to instructions or spend sufficient time reading the instructional texts, was addressed by requiring
participants to complete the materials in a computer lab, during controlled experimental sessions, rather than independently. The second limitation was the poor reliability of scores on the IVT measure of integration. In Experiment 2, many of the items were revised (e.g., new distractor sentences) and the instructions for the measure were simplified to address these limitations. In addition, a new measure of integration was included. This free recall measure, in both written and drawn forms, was incorporated as a large-grain measure of integration to compliment the small-grain measurement of the IVT.

Experiment 2 tested three conditions. The first two conditions, read to comprehend and read to integrate, were identical to the two conditions of Experiment 1. In the third condition, the text integration instructions were accompanied by supplementary information to ensure these instructions were understood. Experiment 2 also included an additional independent variable of text type. There were two levels of this variable, such that half of the participants read the same two texts as in Experiment 1, and the other half read a single text that explained both biological systems. The purpose of this independent variable was to determine if experimental manipulations could help students to integrate separate texts to the same degree as students who were presented the information in combined form.

The main hypothesis tested in Experiment 2 was that students who were informed about the importance of generating connections between two texts and were given the necessary support to understand these instructions would integrate the texts to a greater degree than would participants who were not given this support. The results of the study did not support this hypothesis. There were no differences on posttest measures of integration between participants who were instructed to read to comprehend, read to integrate, or read to integrate with understanding support. In sum, evidence from Experiment 2 provided no evidence that understanding that the texts should be integrated is sufficient for integration to occur.

Despite the fact that participants who read a single combined text had higher integration scores on the verbal free recall integration measure, the instructional supports provided in Experiment 2 were not sufficient to stimulate integration. Thus, Experiment 3 was designed to extend this support by testing an intervention that would help readers accomplish text integration. Participants in Experiments 3a and 3b were assigned to one of three conditions, inspiring integration (II), coaching comprehension (CC), or a control task (CT). In addition, they read either a single combined text or two separate texts. Experiments 3a and 3b were identical with the exception of the
population tested and thus, Experiment 3b serves as a partial replication of Experiment 3a. The main hypothesis tested in these experiments was that students who were provided an integration intervention would be more likely to integrate than participants who received a comprehension intervention or a control task. Overall in Experiment 3a and 3b, participants spent about fifteen seconds reading the instructions, and of all 618 participants, only 37 spent less than five seconds reading them. Furthermore, participants spent nearly twice as long reading the text(s) compared to participants in Experiments 1 and 2.

In both Experiments 3a and 3b, participants in the II condition scored higher on a measure of integration than participants in either the CC or control conditions, even though participants who completed a control task scored significantly higher on a measure of comprehension than participants who received either intervention. The findings are reinforced by the strategies that participants self-reported. Participants in the II condition had significantly higher scores on the ISSI Integration factor and significantly lower scores on the ISSI Separation factor than participants assigned to the CC or CT conditions. These findings suggest that participants who are given an intervention that supports integration, report greater use of integration strategies and score higher on a measure of integration than their counterparts who do not receive specific support for integration. By contrast, participants in the II condition reported less frequent use of Separation strategies in comparison to participants in either CC or CT conditions. Taken together, responses to the ISSI indicate that the intervention significantly impacted the strategies that students used and these strategies affected the knowledge acquired.

**Theoretical Interpretation of the Findings**

There is a need to develop methods to help students in introductory biology course “become adept at making connections among seemingly disparate pieces of information” (AAAS, 2011, p. 3). Moreover, these methods must be practical for instructors to implement. In developing these methods, one must achieve a delicate balance between providing the necessary support without placing undue burdens on either the instructor or the learner, while still providing sufficient conditions for integration to occur.

The process of integrating information is challenging for students. Simply telling students to integrate is not sufficient to produce integration (Britt & Sommer, 2004). Based on the findings reported in this dissertation, this
inability does not appear to be due to a poor understanding of what it means to integrate. Both Experiments 1 and 2 of this research demonstrate that providing instructions to integrate, even with clarification to ensure understanding of the instructions, is not sufficient support to enhance students’ integration. Despite the efforts to stimulate text integration by ensuring that students knew and understood that task requirement, Experiments 1 and 2 showed that individual differences in the Need for Cognition were the only significant predictor of text integration. It is not surprising that participants with a higher Need for Cognition, who enjoy effortful thinking, are better able to navigate the challenges of integrating two biology systems. However, this finding emphasizes the importance of having an intervention that can stimulate integration. Without one, only a small percentage of students with high Need for Cognition will integrate. Not surprisingly, participants’ Need for Cognition also moderated the effect of the intervention on the small-grain integration measure. The strength of the intervention was dependent on participants’ Need for Cognition.

The specific integration intervention tested in this research was based on Kiewra’s SOAR principles (2005; 2009). An inspiring integration (II) intervention was developed, with all four aspects of SOAR (i.e., selection, organization, association, and regulation), to promote integration. The first two components were the S and the O. Participants selected content from the text and took notes by writing information into a provided matrix. Two columns of the matrix were designated for content from the endocrine system and the urinary system and presented side by side to allow for generation of connections between the columns. In the CC intervention, participants received equivalents to the S and O components without facilitating integration. Participants selected content from the text and took notes by writing information into a provided outline. The outline separated information pertaining to the different systems on opposite sides of a sheet of paper. The third component of SOAR is associate. Only participants in the II intervention were asked specific questions to promote the generation of associations between the systems. Participants in the CC condition received comparable questions that only required comprehension of information within a system. Regulation is the fourth component of SOAR. In both conditions, participants were given support to regulate toward the task instructions of their respective condition. Participants in the II condition regulated their ability to integrate, whereas participants in the CC condition regulated their ability to comprehend. Both interventions were driven by the four components of SOAR, but the difference is evident in the emphasis of each component toward either integration or comprehension. A control task (CT) condition was also included. In
this condition, participants completed a control task that only required students to take notes and identify important information within the text. SOAR principles were not followed in this control condition.

Of the three groups, participants in the CT condition scored the highest on a measure of small-grain comprehension in Experiment 3b, while also spending the longest amount of time reading the text(s). Despite lower comprehension scores and less time-on-task, participants in the II intervention still scored significantly higher on the vFRI measure of large-grain integration than participants in either the CC or CT conditions. Thus, the gain in integration scores is not due to either enhanced text comprehension or time-on-task. Furthermore, students in a condition intended to enhance comprehension did not score higher on integration measures than the control. As such these comparisons show that integration requires something beyond enhanced text comprehension.

As expected, participants who read a single combined text scored higher on a large-grain integration measure than participants who read two separate texts. This effect of text type was present even though the single combined text did not provide any explicit connections between the systems. In the single combined text, existing sections from each of the separate texts were placed into a single combined version. The same information was presented in both text types; the only difference was the physical proximity of the information. This finding is consistent with the spatial contiguity effect (Mayer, 2005), where learning is increased when corresponding words and information are presented close together. This may also partially explain the success of the II intervention. One of the features is the side-by-side presentation of columns, according to the spatial contiguity effect this may have allowed participants in the II condition to see the information close together and generate the connections.

The integration intervention tested in this research expands the literature on effective methods for promoting cross-text connections. Others have found that writing summary and argument essays (Gil et al., 2010a; 2010b; Wiley & Voss, 1999) and writing integration essays (Cerdán & Vidal-Abarca, 2008) are also tasks that can be used to prompt integration during reading of multiple texts. Unfortunately, none of these previously tested methods was suitable for the context of the academic task examined in this study. The to-be-learned content of these previous studies involved multiple texts written about the same topic, with each text contributing unique and, in some cases, conflicting information. Though college students certainly encounter texts such as those, they also face the common integration demand of connecting texts that cover different, but related topics. Under these conditions, an intervention such as writing an argument essay does not match the task.
In addition to being well suited to the integration of separate, but related texts, the intervention tested here is also well matched to academic contexts such as the biology courses examined here. For these courses, the matrix used in the II intervention can also be expanded to incorporate additional topics covered in the course. As students read a third chapter, covering the topic of the cardiovascular system, for example, a new column could be added to the matrix for this content. The demand placed on course instructors is minimal, although instructors would likely need to provide the initial matrix (i.e., row prompts) and associative questions relevant for each new topic. Beyond this, the intervention meets the requirements for an intervention that not only stimulates students’ text integration, but also minimizes instructor-demand. The intervention uses existing text resources, and involves tasks that can be completed outside of the classroom.

Another major contribution of this research is the development of the Integration and Separation Strategy Inventory (ISSI). This inventory measures the self-reported strategies used when reading about two different, but related, biological systems. Findings from this inventory indicate that the inspiring integration intervention was effective because this intervention stimulated student engagement toward integration strategies. Students who reported the most frequent use of strategies such as “form[ing] a complete picture of how the endocrine system and the urinary system work together to influence how the human body functions” also obtained the highest scores on the verbal free recall integration measure. This is consistent with other research in that has found relationships between the strategies learners use and integration across to-be-learned content (Bråten & Strømsø, 2011; Turns, et al., in prep). In addition, results from the ISSI indicate that text integration requires cognitive processes beyond within-text comprehension. Students who reported the most frequent use of these separate text comprehension strategies obtained higher scores on a measure of small-grain comprehension, but these strategies did not benefit integration. In short, the research presented here demonstrates the strategies students report relate to the nature of the knowledge representations constructed. These findings are consistent with other work on multiple text readings. In a study by Bråten and Strømsø (2011), for example, there was a significant positive correlation between participants’ self-reported strategy use and scores on a posttest measure of integration. Scores on the MTSI’s Cross-text Elaboration factor were significantly and positively correlated with scores on an IVT integration measure. They also found a significant, negative correlation between participants’ scores on the MTSI’s Accumulation factor and scores
on the IVT integration measure. Furthermore, there were no significant correlations between either factor and measures of comprehension.

Limitations.

Throughout the set of experiments presented in this dissertation, there are two primary limitations. First and foremost is the limitation caused by the poor reliability of scores for several of the measures (See Footnote 1). In Experiment 1, the scores on the PIT measures had such poor internal consistency that the large-grain comprehension measure was not included in any of the analyses. The alpha coefficients of the SVT, PIT, and IVT measures in all three studies are far below the minimum recommended values. This is problematic, but is expounded by the difficulty of the measures. The average score in many cases was only slightly above guessing. For example, in Experiment 3a and 3b scores on the IVT were right around nine out of sixteen.

These measures were problematic in Experiment 1, and as such they were extensively revised for Experiment 2. Additionally, a different measure of integration was added. When the measures did not improve in Experiment 2, they were not revised further for Experiment 3. These low scores with unacceptably low internal consistency may have resulted in the failure to detect differences between the intervention conditions. In fact, the IVT failed to reveal any differences on any measure, except for Need for Cognition in Experiments 1 and 2. Despite the reduction in power as a result of the low reliability of scores, significant differences on both comprehension and integration measures were detected. Comprehension differences were detected on one measure of small-grain comprehension, and integration differences were detected on one large-grain integration measure.

The SVT, PIT, and IVT measures were developed according to Royer’s (1990) standards, and have been used by other researchers studying multiple-text integration. Though the reliability of these measures is troublesome and precludes generalization beyond the sample studied here, other research provides evidence that the measures used here are valid indicators of the respective measured variables (cf. Bråten & Strømsø, 2010; Bråten, Strømsø, & Samuelstuen, 2008; Strømsø, Bråten, & Samuelstuen, 2008). Findings from these studies suggest that the measurement approach used here is appropriate for capturing the behaviors of interest. Nonetheless, the unacceptably poor score reliabilities suggests these measures may not be adequate for capturing comprehension and
integration when students read text such as those read in this research. One possible for the low internal consistencies reported here is that the two biology texts are substantially longer and more complex than the texts used by Royer (1990). The texts used in Royer’s research were 12-item tests built off of 12-sentence passages. Continuing to refine the measurement of integration will be necessary to support future research on integration interventions.

The second major limitation of this dissertation research is the suspected lack of investment on the part of participants. The initial intention of the study was to generalize to a population of college students studying from their textbook. This intended audience has motivation to engage with course materials in order to achieve good grades, unlike the samples in Experiments 1 and 3. The lack of investment was evident in Experiment 1, where over 20% of participants spent less than five seconds reading the 35-word instructions. More troubling, these students spent only 10 minutes on average reading two lengthy instructional texts. Experiment 2 addressed this limitation by having students complete the study in a lab in order to increase the experimental control. Yet, the lack of investment was still evident in Experiment 2, where approximately 10% of the participants spent less than five seconds reading the instructions, and participants spent 16 minutes on average reading the instructional materials. Given this time data, it is not surprising that overall participants did not perform well on the posttest measures. In Experiment 3a and 3b, this limitation was directly addressed by providing participants additional incentive to study the material as well as providing an intervention to complete during the session. The percentage of participants that spent less than five seconds reading the instructions was reduced to less than 6%, and the time participants spent reading the instructional materials increased to about 21 minutes.

**Future Directions**

Future research should test the effects of this intervention within the larger context of a biology course covering this content. Because students engaged in the intervention under relatively artificial experimental conditions, further research is necessary to consider if students are able to integrate using these materials under more ecologically valid conditions. This research could be conducted by implementing the matrix as a recurring
homework assignment. Throughout the semester, students in an introductory anatomy and physiology course could build a matrix with all of the systems of the body, while answer corresponding associative and regulative questions.

Additionally, the newly developed ISSI, appears to be a promising measure of self-report integration and separation strategy use. The measure used in Experiment 3 was the first implementation of this measure. Future research on the ISSI should address the items that failed to load onto the factors and test the use of the measure in other multiple-text situations. Furthermore, the match between intervention delivered and self-reported strategy use should be considered. The results from Experiment 3 suggest that when participants are given support to integrate via the inspiring integration intervention, they think they are using integration strategies. This immediately begs the question, “Are they?” The results from the dependent measures of Experiment 3 indicate that they may be. To further test this, a follow-up study should be conducted that replicates the procedures while collecting eye-gaze and think aloud data. Triangulating the ISSI with posttest measures, verbal protocols, and eye-gaze patterns could provide valuable insight into the cognitive processes of participants as they integrate or fail-to-integrate between the two biology systems. Additionally, these findings would shed light on the significant differences in time that participants in Experiment 3 spent reading the text(s).

**Final Thoughts**

The purpose of this dissertation was to develop a method to achieve an instructor-independent intervention that facilitates biology students’ integration of concepts between multiple texts. Through a set of three consecutive experiments, an intervention was developed and tested to support the integration of concepts between biological systems. The research question driving the research was, “Do participants given an instructional task to integrate and a reminder of the task with an opportunity to practice integration and given an intervention to inspire integration generate more connections between multiple texts than those given an intervention centered only on comprehension or a control task?” While the results were somewhat mixed, the experiments contained herein answered the question in the affirmative.
References


Appendices

Appendix A - Experiment 1

Implied Informed Consent Form (Experiment 1)
Demographics (Experiment 1/Experiment 2/Experiment 3)
Biology Prior Knowledge (Experiment 1/Experiment 2/Experiment 3)
Need for Cognition (Experiment 1)
Rubric for Task Instructions Verification (Experiment 1/Experiment 2)
The Endocrine System Text (Experiment 1/Experiment 2/Experiment 3)
The Urinary System Text (Experiment 1/Experiment 2/Experiment 3)
Sentence Verification Technique Measure - Endocrine Text (Experiment 1/Experiment 2/Experiment 3)
Sentence Verification Technique Measure - Urinary Text (Experiment 1/Experiment 2/Experiment 3)
Principle Identification Technique - Endocrine Text (Experiment 1)
Principle Identification Technique - Urinary Text (Experiment 1)
Inference Verification Technique Measure of Integration (Experiment 1)
Implied Informed Consent Form (Experiment 1)

The Pennsylvania State University

Title of Project: Text Comprehension in Biology
Principal Investigator: Carla Firetto, Graduate Student
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Advisor: Dr. Peggy Van Meter
368 Frear Building
University Park, PA 16802
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1. Purpose of the Study: The purpose of this research study is to explore how college students read and understand texts.

2. Procedures to be followed: You will be asked a series of questions about what you know and how you think and then you will be given instructions and asked to read text about biology content and then respond to a series of questions about what you have read.

3. Duration: It will take about one hour to complete the entire procedure.

4. Statement of Confidentiality: Your participation in this research is confidential. The researcher would use ID information only to inform the teacher about extra credit. Once this is completed, the ID would be destroyed or stored separately from the data. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared because your name is in no way linked to your responses. Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

5. Right to Ask Questions: Please contact Carla Firetto at cmf270@psu.edu with questions or concerns about this study.

6. Payment for participation: Participants will receive 5 extra credit points for their Biology course. There is another option to participating to receive the extra credit. This option is to read an article related to this research and prepare a one-page reaction to it. Please e-mail Carla Firetto at cmf270@psu.edu for more information.

7. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and submission of the survey implies that you have read the information in this form and consent to take part in the research. Please print this form for your records or future reference.

The link to begin the survey is: https://pennstate.qualtrics.com/SE/?SID=SV_1ZXfr7Tyvn6Hogc
Demographics (Experiment 1/Experiment 2/Experiment 3)

NOTE: PLEASE READ ALL INSTRUCTIONS VERY CAREFULLY!

Thank you for your participation, please take your time to complete this survey.

It will take about 1 hour of your time, at the end you will be asked to enter your user ID that will be recorded upon submission and used to inform your instructor of participation.

Age

Sex
- Male
- Female

Race/Ethnicity
- American Indian
- Asian
- Black
- Hispanic
- Pacific Islander
- White
- Other (optional: enter below)
- Prefer not to say

Not including the current semester, Spring 2012, how many semesters of college have you completed?

Please indicate your current grade point average (GPA)

Current Major
- Education Related Major (please specify)
- Biology
- Biology Related Major (Biobehavioral Health, Biotechnology, Biochemistry, etc.) (please specify)
- Other

Next
Biology Prior Knowledge (Experiment 1/Experiment 2/Experiment 3)

On the next page you will be asked to respond to a series of multiple-choice questions. The questions are related to various content areas within the field of biology. These questions may cover content that you have not learned or do not know.

Select the best choice for each of the following 10 items.

The graph above depicts the frequency of expression of the range of leg lengths in a population of grazing animals. In this species, leg length is directly related to speed, which is a heritable characteristic. These grazers are being preyed on by a newly introduced species of swift-running predators. Which of the following graphs represents the range of expression most likely to result from this selection pressure over a long period of time?

Which of the following cellular processes normally produces ATP from glucose in the absence of oxygen?

- Krebs cycle
- Glycolysis
- Chemiosmosis
- Calvin cycle
Which of the following mechanisms can best account for the higher concentrations of mineral nutrients in the root cells of vascular plants than in the surrounding soil environment?

- Osmosis
- Diffusion
- Facilitated diffusion
- Active transport

A person touches a hot object and immediately moves her finger away from it. Which of the following structures is the first to receive an impulse triggered by the stimulus?

- Synapse
- Ventral root ganglion
- Motor neuron
- Sensory neuron

Directions for the Following Two Questions: The group of questions below describes an experimental situation. First study the description of the situation; then choose the one best answer for each question.

Sickle cell anemia is a genetic disorder. Specialized techniques for DNA analysis are used to detect carriers of the sickle cell anemia allele and infants that are homozygous for the trait. The DNA is cut into fragments that are separated according to size by use of gel electrophoresis. Radiolabeled probes can then be used to identify both the normal allele and the mutant (sickle cell) allele.

The reference data shown below indicate that the DNA in lane I is from a noncarrier (AA) the DNA in lane II is from a carrier (AS), and the DNA in lane III is from an individual having sickle cell anemia (SS). The sample data are from two parents (lanes I and II) and their infant (lane III).

Which of the following is correct concerning the sickle cell trait in Parent 1 (lane I)?

- Parent 1 is a carrier (AS).
- Parent 1 is a noncarrier (AA).
- Parent 1 has sickle cell anemia (SS).
- The occurrence of the sickle cell trait cannot be determined from the data.

Which of the following can be concluded from the sample data?

- The infant is homozygous for the sickle cell allele (SS).
- The infant is a carrier of the sickle cell allele (AS).
- The infant is a noncarrier of the sickle cell allele (AA).
- The occurrence of the sickle cell trait cannot be determined for the infant.
Directions for the Following Two Questions: The group of questions below consists of four lettered headings followed by a list of phrases or sentences. For each sentence, select the one heading that is most closely related to it. One heading may be used once, more than once, or not at all.

Nephrons
Flame cells
Malpighian tubules
Skin gills

Function in both arachnids and insects

(A) Nephrons
(B) Flame cells
(C) Malpighian tubules
(D) Skin gills

Have cilia to drive waste products to excretory pores

(A) Nephrons
(B) Flame cells
(C) Malpighian tubules
(D) Skin gills

Which of the following is a unit for density?

- kg
- kg/m
- g/m
- m/sec

<table>
<thead>
<tr>
<th>Test Tube</th>
<th>Materials Added</th>
<th>Initial Color</th>
<th>Final Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aquatic plant, bromothymol blue solution</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>2</td>
<td>Aquatic plant, bromothymol blue solution, carbonated water</td>
<td>Yellow</td>
<td>Blue</td>
</tr>
<tr>
<td>3</td>
<td>Bromothymol blue solution, carbonated water</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

In a lab investigation designed to demonstrate one aspect of photosynthesis, three tubes were treated as shown above. The test tubes were then placed under a bright lamp for 24 hours. Which of the following is the best explanation for the observed color change in tube 2?

- The light bleached the solution from its original color of yellow to blue.
- The aquatic plant produced carbon dioxide, which changed into carbonic acid and caused the color change.
- The aquatic plant used carbon dioxide, raising the pH of the solution.
- The plant produces oxygen during photosynthesis, which caused the color change.
Need for Cognition (Experiment 1)

For each of the statements below, please indicate whether or not the statement is characteristic of you or of what you believe. For example, if the statement is extremely uncharacteristic of you or of what you believe about yourself (not at all like you) please move the slider to the "1" on the line to the right of the statement. If the statement is extremely characteristic of you or of what you believe about yourself (just like you) please move the slider to the "5" on the line to the right of the statement. You must click on the slider to enter your response for each item, even if you intend the slider to be at 1.

Be assured there is NO correct or incorrect response to any of these statements, each response only reflects degrees to which you feel the statements are representative of you.

<table>
<thead>
<tr>
<th></th>
<th>Not at all like me</th>
<th>Not much like me</th>
<th>Somewhat like me</th>
<th>Quite a lot like me</th>
<th>Just like me</th>
</tr>
</thead>
</table>

1. I would prefer complex to simple problems.
2. I like to have the responsibility of handling a situation that requires a lot of thinking.
3. Thinking is not my idea of fun.*
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.*
5. I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something.*
6. I find satisfaction in deliberating hard and for long hours.
7. I only think as hard as I have to.*
8. I prefer to think about small, daily projects to long-term ones.*
9. I like tasks that require little thought once I’ve learned them.*
10. The idea of relying on thought to make my way to the top appeals to me.
11. I really enjoy a task that involves coming up with new solutions to problems.
12. Learning new ways to think doesn’t excite me very much.*
13. I prefer my life to be filled with puzzles that I must solve.
14. The notion of thinking abstractly is appealing to me.
15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.*
17. It’s enough for me that something gets the job done; I don’t care how or why it works.*
18. I usually end up deliberating about issues even when they do not affect me personally.

*Indicates reverse coded item.
Rubric for Task Instructions Verification

**Verified Instructions:**

**Yes – From Integrate Condition:**
Needs to “understand that the purpose of the task is to integrate the texts”
Must use some form of the word “Connect, relate, combine, compare, etc” with respect to the texts, to show that the purpose is to integrate, or otherwise indicate a connection (together, a whole, etc).

Examples:
“I am to read both texts and study how the material is related”
“Research shows that if you combine both texts you will comprehend it more efficiently”
“Read the following two readings/ While doing so, try to relate one to the other. It has been shown that it is possible to make connections between the two while you are reading”
“understand as a whole…”

**Yes – From Comprehend Condition:**
Needs to “understands that the purpose of the task is to comprehend the texts”
Must use some form of the word “read, comprehend, understand, study, etc” with respect to the texts to show that the purpose of the study is to read the texts.

Examples:
“I will have to read a textbook carefully and then answer questions based on what I have read.”
“I skimmed the instructions and did not capture any detail. I simply read for the main idea…”
“Read the following two readings/ While doing so, try to relate one to the other. It has been shown that it is possible to make connections between the two while you are reading”
“understand as a whole…”

**No Verification of Instructions:**

**No - From Either Condition**
“may have some rudimentary wording from the instructions, but is vague or unrelated to the main point”
Examples are wide ranging and may include:
“Read the directions carefully”
“Questions cannot be combined”
“Studies have shown that you can learn better if things are marked in text”
“The instructions were explaining instructions about biology text”
“I have no idea”
“Please continue with the survey until it is completed. Read Carefully”
The Endocrine System Text (Experiment 1/Experiment 2/Experiment 3):

The Endocrine System

If the body is to function as an integrated whole, its organs must communicate with each other and coordinate their activities. Even very simple organisms composed of only a few cells have mechanisms for intercellular communication, suggesting that such mechanisms evolved very early in the history of life. In humans, one such system is the endocrine system, which communicates with chemical messengers called hormones. This text is primarily about the endocrine system of communication, or endocrinology, the study of hormones and how they travel through the blood. It will address both the large-scale components such as the anatomy of the hypothalamus and the pituitary glands and more detailed components of the hormones and how they stimulate and inhibit cells, tissues, and organs. See Figure 1 for a graphic representation of how hormones travel through the circulatory system.

Figure 1: Hormones travel through the circulatory system to stimulate their target cells.

The body has four principle avenues of intercellular communication, but the primary way the endocrine system communicates is through hormones. Hormones, in the strictest sense, are chemical messengers that are transported by the bloodstream and stimulate physiological responses in cells of another tissue or organ, often a considerable distance away. The glands, tissues, and cells that secrete hormones constitute the endocrine system: the study of this system and the diagnosis and treatment of its disorders is called endocrinology.

Unlike other systems, there is no master control center that regulates the entire endocrine system, but the pituitary gland and the hypothalamus have a more wide-ranging influence than any other part of the system.

Hypothalamus
The hypothalamus, shaped like a flattened funnel, is at the bottom part of the brain. It regulates primitive functions of the body ranging from water balance and thermoregulation to sex drive and childbirth. Many of its functions are carried out by way of the pituitary gland, which is closely associated with the hypothalamus both anatomically and physiologically. Figure 2 illustrates the hypothalamus.

Pituitary Gland
The pituitary gland is suspended from the floor of the hypothalamus by a stalk and housed in a depression of the sphenoid bone. The pituitary gland is roughly the size of a kidney bean, usually about 1.3 cm wide; it grows about 50% larger in pregnancy. The pituitary gland is actually composed of two structures; the anterior pituitary, which constitutes the anterior three-quarters of the pituitary and the posterior pituitary, which constitutes the posterior one-quarter of the pituitary, each has separate functions but they are so closely joined that they look like a single gland. Figure 2 illustrates the anterior and posterior pituitary glands.
Communication between the Hypothalamus and the Pituitary gland

The anterior pituitary has no nervous connection to the hypothalamus but it is linked to the hypothalamus through a complex of blood vessels called the hypophyseal portal system. The hypothalamus controls the anterior pituitary by secreting hormones that enter the hypophyseal portal system, and then enter the anterior pituitary tissue. There are six hormones that are secreted by the hypothalamus to regulate the anterior pituitary gland, these hormones may either stimulate pituitary cells to secrete hormones or inhibit the pituitary hormone secretions to regulate the function of various organs or tissues. For example, Luteinizing hormone (LH) stimulates the ovaries to release an egg (ovulation) in females and growth hormone (GH) stimulates mitosis and widespread bone, liver, and muscle growth.

The posterior pituitary is not technically a true gland but is actually nervous tissue. The nerve fibers arise from certain cell bodies in the hypothalamus, pass down the stalk as a bundle and end in the posterior pituitary. The hypothalamic neurons synthesize hormones and transport them down the axons to the posterior pituitary where they are stored until a nerve signal triggers their release into the blood. Unlike the anterior pituitary, these hormones are synthesized in the hypothalamus and are stored in the pituitary for release on command. For example, antidiuretic hormone (ADH), secreted by the hypothalamus, increases water retention by signaling the cells of the distal convoluted tubule and collecting duct to create aquaporins, thus reducing urine volume and preventing dehydration. In extreme situations, ADH may also cause vasoconstriction throughout the body.
Other Endocrine Glands
The parathyroid glands consist of three or four ovoid glands partially embedded in the posterior surface of the thyroid. The parathyroid glands secrete parathyroid hormone (PTH) in response to hypocalcaemia to raise blood calcium levels. Parathyroid hormone acts on the Loop of Henle in the nephron to increase calcium reabsorption. See Figure 3 for a visual of the parathyroid glands.

The kidneys sit in the posterior part of the abdominal cavity and regulate the volume and composition of body fluids. When filtrate flows slowly through the nephron (due to low blood pressure), specialized kidney cells secrete the enzyme renin, which activates a cascade of hormones throughout the body called the renin-angiotensin system. The hormone angiotensin II is ultimately produced and acts as a powerful vasoconstrictor, thus raising blood pressure. Angiotensin II also stimulates aldosterone and ADH release.

The adrenal glands sit like a cap on the superior surface of each kidney. Like the pituitary gland, they consist of two parts, the adrenal medulla and the adrenal cortex. The adrenal medulla acts both as an endocrine gland and as a ganglion of the sympathetic nervous system. The adrenal cortex surrounds the medulla and produces a number of steroid hormones, such as aldosterone, which acts on the nephrons and causes them to reabsorb more ions, which then draw water, into the body. See Figure 3 for a visual of the adrenal glands.

Hormones
Most hormones fall into three chemical classes: steroids, peptides, and monoamines. Steroids are synthesized from cholesterol and differ mainly in the four-ringed steroid backbone. Examples of steroid hormones include sex hormones produced by the testes and ovaries (such as estrogens and testosterone) and corticosteroids produced by the adrenal gland (such as aldosterone and cortisol). Peptides are chains of 3 to 200 or more amino acids and are synthesized the same way as any other protein. Examples of peptide hormones include hormones produced by the posterior pituitary (such as antidiuretic hormone and oxytocin) and the kidneys (such as renin and angiotensin). Monoamines are also made from amino acids and include several neurotransmitters (such as dopamine and melatonin). See Figure 4 for the chemical structures of these three hormones.

Hormones

Figure 4: Chemical structures of (a) steroid, (b) monoamine, (c) peptide hormones.

To get to a target cell, a hormone must travel in the blood, which is mostly water. Most of the monoamines and peptides are hydrophilic (water loving), so mixing with the blood plasma presents no problem for them. Steroids, however, are hydrophobic (water fearing) and must bind to hydrophilic transport proteins to get to
their destination. The transport proteins are albumins and globulins synthesized by the liver. A hormone attached to a transport protein is called a bound hormone and one that is not attached is an unbound hormone. Only the unbound hormone can leave a blood capillary and get to a target cell. Transport proteins not only enable hydrophobic hormones to travel in the blood, but also prolong their half-lives. They protect circulating hormones from being broken down by enzymes in the blood plasma and liver, and also prevent them from being filtered out of the blood by the kidneys. Unbound hormones may be broken down or removed from the blood in a few minutes, whereas bound hormones may circulate for hours or weeks. Steroid hormones bind to globulins such as transcortin, the transport protein for cortisol. Aldosterone is unusual, and has no specific transport protein but binds weakly to albumin and others. However, 85% of it remains unbound and, correspondingly, has a half-life of only 20 minutes.

Hormones stimulate only those cells that have receptors for them. The receptors or protein or glycoprotein molecules located on the plasma membrane, in the cytoplasm, or in the nucleus. They act like switches to turn certain metabolic pathways on or off when the hormone binds to them. A target cell usually has a few thousand receptors for a given hormone.

Steroid hormones enter the target cell nucleus and act directly on the genes, changing target cell physiology by activating or inhibiting transcription of the gene for a metabolic enzyme or other protein. Being hydrophobic, they diffuse easily through the phospholipid-cholesterol regions of the plasma membrane. Most of them pass directly into the nucleus. In either case, the receptor associates with the target gene in the nucleus, controlling its transcription. Estrogen and progesterone afford a good example of the action of steroid hormones. In cells of the uterine mucosa, estrogen and its nuclear receptor activate a gene for the protein that functions as the progesterone receptor. See Figure 5 for a depiction of a steroid hormone entering a target cell.

Figure 5: Steroid hormone transport to target cell.

Peptides and monoamines are hydrophilic and cannot penetrate into a target cell, so they must stimulate its physiology indirectly. They bind to the cell surface receptors, which are linked to second messenger systems on the other side of the plasma membrane. The best-known second messenger is cyclic adenosine monophosphate (cAMP). When glucagon binds to the surface of a liver cell, for example, its receptor activates a G protein, which in turn activates adenylate cyclase, the membrane enzyme that produces cAMP. cAMP leads ultimately to the activation of enzymes that hydrolyze glycogen stored in the cell. The general point is that the hydrophilic hormones cannot enter the target cell. Yet by merely “knocking on the door” (binding to a surface receptor) they can initiate a flurry of metabolic activity within the cell. Ultimately these pathways lead to metabolic pathways being switch on or off within the cell. Hormonal effects mediated through surface receptors tend to be relatively quick, because they do not depend on the cell synthesizing new proteins before anything else can happen. See Figure 6 for a depiction of a peptide hormone in comparison to a steroid hormone.
Feedback from Target Organs
The regulation of other endocrine glands by the pituitary is not simply a system of “command from the top down.” Those target organs also regulate the pituitary and hypothalamus through various feedback loops. Most often this takes the form of negative feedback inhibition—the pituitary stimulates another endocrine gland to secrete its hormone and that hormone feeds back to the pituitary or hypothalamus and inhibits further secretion of the pituitary hormone.
The Urinary System

The function of your urinary system is much more than simply producing urine. The urinary system regulates the volume and composition of all of your body fluids: the blood, the cerebral spinal fluid bathing your brain, the interstitial fluid surrounding all of your cells, and the intracellular fluid within those cells. It would be impossible to excrete metabolic waste or maintain a healthy blood pressure, salt balance, and water balance without the urinary system. The principle organs of the urinary system are the kidneys.

All of the fluids in your body connect to one another at some point, usually by coming into direct or indirect contact with the blood. Throughout your body, nutrients and water leave the blood to nourish cells, and waste products diffuse from the cells and enter the blood. Your circulatory system transports nutrients, waste, and other chemicals from all over the body to the kidneys. An average sized person has approximately five quarts of blood, so to regulate the levels of salts and other nutrients, and to prevent waste products from building up throughout the body, every drop of blood is filtered through the kidneys approximately 60 times per day.

Your kidneys are the pair of organs located in the small of your back just below your ribs. Each kidney is about the size of a standard computer mouse. Blood enters and leaves each kidney through a renal artery and renal vein. The kidneys excrete urine, which is composed of metabolic waste products, excess water and salts, and other molecules. The ureters, a pair of narrow tubes, transport urine from the kidneys to the urinary bladder. Urine is stored in the bladder until it is expelled from the body through the urethra, the tube connecting the bladder to the outside world. See Figure 1 for anterior and posterior views of this system.

Figure 1: Anterior (a) and posterior (b) views of the kidneys in the abdominal cavity.

Internally, the kidney is divided into three regions, the renal cortex, medulla, and pelvis. The renal medulla is composed of a series of triangular structures called renal pyramids. Each pyramid ends in a rounded point called a renal papilla. Blood circulates throughout the renal cortex and renal medulla, and this is where the kidney regulates the volume and composition of the fluid, forming urine in the process. The newly formed urine drips from the renal papillae of the renal pyramids and is collected by a series of small funnels (major calyx and minor calyx). These small funnels channel the urine into a large funnel, the renal pelvis, which then passes the urine to the ureter for transport to the bladder. See Figure 2 for a cross section of the kidney depicting these structures.
Within the renal cortex and medulla, the blood comes into contact with millions of specialized tubes called nephrons. The nephron is the functional unit of the kidneys; it is the nephrons that regulate the volume and composition of the blood passing through the kidney. A nephron is composed of four parts: Bowman’s capsule, the proximal convoluted tubule, the Loop of Henle, and the distal convoluted tubule. Blood vessels come into contact with every part of the nephron and allow water and solutes to pass between the blood and the fluid in the nephron.

Bowman’s Capsule
The blood that entered the kidney through the renal artery is distributed into millions of little arteries. The smallest arteries, called afferent arterioles, bring blood to Bowman’s capsule. The afferent arterioles actually branch out to form a ball of tiny capillaries called the glomerulus. Bowman’s capsule surrounds the glomerulus. The walls of the glomerular capillaries are leaky, and the blood pressure drives water, salts, waste products, and other small hydrophilic molecules out of the capillaries and into Bowman’s capsule. Once inside Bowman’s capsule, the fluid is called filtrate. The filtrate is a mix of water, nutrients needed to remain healthy, and waste products that need to be eliminated. See Figure 3 for an illustration of the nephron, and in particular the peritubular capillaries and the glomerulus.

It is important to note that only a small sample of the blood in the glomerulus filters out to become filtrate in Bowman’s capsule. Most of the blood, including large proteins and other molecules, is not filtered at all, and flows instead into the efferent arteriole. The efferent arteriole carries the blood to the peritubular capillaries, which surround the next part of the nephron, the proximal convoluted tubule.
Proximal Convoluted Tubule

The filtrate pressure in Bowman’s capsule, determined by blood pressure, pushes the filtrate into the next region of the nephron, the proximal convoluted tubule. Remember that the filtrate contains both nutrients and waste products. Active transport proteins in the membrane of the proximal convoluted tubule transport nutrients like salts, sugars, and amino acids out of the nephron and toward the blood inside the peritubular capillaries. There are no active transport proteins specific for waste products, so they are left behind in the filtrate of the proximal convoluted tubule. Imagine cleaning your bedroom by throwing everything in your room into the garbage, including your favorite books and posters, along with the scrap paper, food wrappers, and other waste. If you then transported your books and posters back into your bedroom, leaving the waste behind, you would be cleaning your bedroom in a way that is similar to how the nephron cleans the blood. See Figure 4 for a graphic representation of the flow of filtrate through the nephron.

![Figure 4: Flow of filtrate through the nephron.](image)

The nutrients that were transported out of the proximal convoluted tubule and entered the peritubular capillaries will flow into the capillaries of the vasa recta next. The filtrate still contains solutes that are needed by a healthy body, especially water and salts. This filtrate flows out of the proximal convoluted tubule and into the next region of the nephron, the Loop of Henle. The vasa recta are the capillaries surrounding the Loop of Henle.

Loop of Henle

Two connecting tubes, a descending limb and an ascending limb, comprise the Loop of Henle. Filtrate leaving the proximal convoluted tubule enters the descending limb of the Loop of Henle, where water is absorbed (via osmosis) back into the blood within the vasa recta. Again, not every drop of water is absorbed back into the blood, just some of it. As the filtrate passes through the descending limb and enters the ascending limb of the Loop of Henle, active transport proteins in the membrane of the ascending limb transport salts (i.e., sodium, calcium, chloride, and potassium) out of the nephron and toward the blood inside the vasa recta. Some of these salts dissolve into the extracellular fluid and provide the solute gradient that drives osmosis out of the descending limb of the Loop of Henle. See figure 5 for more detail regarding absorption and secretion in the nephron.
Figure 5: Absorption and secretion in the nephron

Water and salts are absorbed into the blood and secreted by the Loop of Henle, and waste products are, for the most part, left behind. The water and salts that have been absorbed eventually pass into the capillaries of the vasa recta. The blood within the vasa recta flows into another set of peritubular capillaries. These capillaries surround the last section of the nephron, the distal convoluted tubule.

Distal Convoluted Tubule
The filtrate remaining in the ascending limb of the Loop of Henle flows into the distal convoluted tubule. At this point, the composition of the filtrate is very different from its composition in Bowman’s capsule. Most of the water, salts, and other nutrients have been absorbed back into the blood stream. As water has left the filtrate, the concentration of the waste molecules has increased. Anything not absorbed back into the blood stream will become part of the urine. The distal convoluted tubule fine tunes the composition of the urine, absorbing ions, nutrients, and water that the body may need and passing them to the blood within the peritubular capillaries. It also transports additional waste products out of the blood and into the distal convoluted tubule for disposal in the urine. See Figure 6 for the absorption of water and salts in the Loop of Henle.

Figure 6: Absorption of water and salts in the Loop of Henle

Blood in the peritubular capillaries eventually passes into small veins, which merge into larger veins, and then drain into the renal vein. The renal vein of each kidney carries blood to the inferior vena cava, the large vein that returns blood to the heart. The distal convoluted tubule is the very last part of the nephron. Filtrate in the distal convoluted tubule passes into a larger tube, the collecting duct, where a little more fine tuning is possible before urine if finally formed.

Collecting Duct
Each collecting duct receives filtrate from many nephrons, and transports that filtrate to the papilla of the
renal pyramid. Once the filtrate drips out of the collecting duct opening at the papilla, the fluid is called urine and its composition cannot be adjusted anymore. However, while the filtrate is still in the collecting duct, water can be reabsorbed into the body if needed. The water passes out of the collecting duct through water pores, called “aquaporins”, and enters the circulatory system through the vasa recta and peritubular capillaries discussed above.

Summary
Depending on the body’s need, you can excrete large amounts of a very watery urine or you can excrete small amounts of a very concentrated urine. The final composition of your urine depends on how much salt, water, or other substances you need to retain or eliminate to maintain a healthy internal environment. As your blood passes through your kidneys, its composition is changed. As that blood travels to the rest of your body, the blood changes the composition of the other body fluids by gaining or losing water and solutes, and those other body fluids change the composition of the blood as well. When the blood returns to the kidneys, the whole process starts again.
You will now be asked to respond to a series of statements about the text you have just read, entitled "The Endocrine System". You will be presented with 16 sentences and asked to judge whether or not each sentence has the same meaning as a sentence that appeared in "The Endocrine System" text.

You will respond to each sentence by deciding if it has the same meaning as a sentence from this text. Mark "Yes" if you believe a sentence has the same meaning as a sentence from the text. Mark "No" if you believe a sentence has a different meaning than a sentence from the text.

Even very simple organisms composed of only a few cells have mechanisms for hypophyseal communication, suggesting that such mechanisms evolved very early in the history of life.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?
- Yes
- No

The endocrine system is composed of glands, tissues, and hormones secreted by cells, and endocrinology is the study, diagnosis, and treatment of its disorders.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?
- Yes
- No

Unlike other systems, there is no master control center that regulates the entire endocrine system, but the pituitary gland and the hypothalamus have a more wide-ranging influence than any other part of the system.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?
- Yes
- No

The pituitary gland is actually composed of two structures; the anterior pituitary, which constitutes the anterior three-quarters of the pituitary and posterior pituitary, which constitutes the posterior one-quarter of the pituitary, both have the same functions because they are so closely joined that they look like a single gland.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?
- Yes
- No
While it has no nervous connection to the hypothalamus, the anterior pituitary is in fact connected with the hypothalamus by the blood vessel group known as the hypophyseal portal system.

The parathyroid glands secrete parathyroid hormone (PTH) in response to hypocalcaemia to raise blood calcium levels.

Melatonin, a monoamine, is synthesized from serotonin during the night, and its secretion fluctuates seasonally.

The difference between the endocrine system and the exocrine system is the presence or absence of ducts; most exocrine glands secrete through ducts, where endocrine glands are ductless and release secretions into the bloodstream.

Most hormones fall into four chemical classes: steroids, peptides, monoamines, and adrenals.

The majority of peptides and monoamines are hydrophilic (water loving), allowing them to easily combine with the blood’s plasma.
A target cell usually has a few thousand receptors for a given hormone.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?

- Yes
- No

Steroids are hydrophilic and cannot penetrate into a target cell, so they must stimulate its physiology indirectly.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?

- Yes
- No

By binding to a surface receptor, hydrophilic hormones will cause a rush of metabolic activity within the target cell.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?

- Yes
- No

The regulation of other endocrine glands by the pituitary is not simply a system of “command from the top down.”

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?

- Yes
- No

Paracrine messengers are chemical signals released by cells into the tissue fluid; they do not travel to their target cells through blood, but diffuse from their source to nearby cells.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?

- Yes
- No

Inadequate hormone release is called hyposecretion, and it often results from tumors or lesions that destroy the endocrine glands.

Does this sentence have the same meaning as a sentence from "The Endocrine System" text?

- Yes
- No

You have completed this set of questions, please click next to continue to the next part.
Sentence Verification Technique Measure - Urinary Text (Experiment 1)

You will now be asked to respond to a series of statements about the text you have just read, entitled "The Urinary System". You will be presented with 16 sentences and asked to judge whether or not each sentence has the same meaning as a sentence that appeared in "The Urinary System" text.

You will respond to each sentence by deciding if it has the same meaning as a sentence from this text. Mark "Yes" if you believe a sentence has the same meaning as a sentence from the text. Mark "No" if you believe a sentence has a different meaning than a sentence from the text.

It is only by the work of the urinary system that our bodies can excrete metabolic waste or maintain a healthy blood pressure, and salt and water balance.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?

- Yes
- No

An average sized person has approximately five quarts of blood, so to regulate the levels of salts and other nutrients, and to prevent waste products from building up throughout the body, every drop of blood is filtered through the kidneys approximately 60 times per day.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?

- Yes
- No

Urine is stored in the urethra until it is expelled from the body through the bladder, the tube connecting the bladder to the outside world.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?

- Yes
- No

Urine is formed by the circulation of blood through both the renal cortex and renal medulla, where the kidney regulates the blood’s volume and composition of the blood.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?

- Yes
- No
Within the renal cortex and medulla, the blood comes into contact with millions of specialized tubes called nephrons.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

Remember that the filtrate contains only waste products.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

Phosphate homeostasis is not as critical as that of other electrolytes because the body can tolerate much greater variations from normal.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

The pH of urine ranges from 4.5 to 8.2 but is usually about 6.0 and is mildly acidic.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

Think about throwing all of your belongings into the trash, including your textbooks and important bills, along with garbage such as candy wrappers and other waste.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

The vasa recta are the capillaries surrounding the Loop of Henle.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No
Water and salts are secreted from the blood and absorbed by the Loop of Henle, and waste products are, for the most part, left behind.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

The distal convoluted tubule absorbs ions, nutrients, and water needed by the body to modify the content of the urine, passing them to the blood in the peritubular capillaries.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

Once the filtrate drips out of collecting duct opening at the papilla, the fluid is called urine and its composition cannot be adjusted anymore.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

Depending on the body’s need, you can excrete large amounts of a very watery urine or you can excrete large amounts of a very concentrated urine.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

The yellow color of urine is due to urochrome, a pigment produced by the breakdown of hemoglobin.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

When urine enters the ureter and stretches it, one of the three layers contracts and initiates contractions to bring urine down to the bladder from the renal pelvis.

Does this sentence have the same meaning as a sentence from "The Urinary System" text?
- Yes
- No

You have completed this set of questions, please click next to continue to the next part.
Principle Identification Task - Endocrine Text (Experiment 1)

Your final task is to think about the materials you have read today, and consider each the four statements below and judge whether or not the concept or principle exhibited in the statement is related or similar to that presented in "The Endocrine System" text.

Shawn was using a potholder in one hand to remove a hot pan from the oven. Because the pan was fuller than he expected, it started to tip when he instinctively reached with his other hand to prevent the pan from falling. The instant he touched the pan with his bare hand, electrical signals traveled along nerves, stimulating a motor response in his arm muscles to remove his hand from the hot surface. The pan fell to the ground, and even though the pan did not break, the electrical signals from the hot pan caused his the heart to pump blood through the body.

- Yes
- No

A junior varsity quarterback was at football practice when he fumbled the ball and was tackled. During the tackle, his right leg broke when it got caught under another player. He had a compound, tibial-fibular fracture, and torn meniscal cartilage. Because the bone broke through the skin, he had to remain in the hospital for some time due to an infection before his leg could be cast. Unfortunately, even though the bones healed, the boy continued to have swelling (“water on the knee”) and pain in his knee. After six months, an x-ray revealed that his meniscus was still torn.

- Yes
- No

Susan wants to get a new dog and she is trying to convince her landlord that a dog will not be a nuisance for the rest of the apartment complex. If she is going to defend her position to her landlord, she knows that she needs to have a rebuttal for many different kinds of arguments, and she wants to be prepared. She has gathered resources from popular television shows, like animal planet and discovery channel, and discussed her issue with the sales representative at her local pet supply store, a dog breeder, and a website forum for people who own dogs and live in small apartments.

- Yes
- No

A New York City Law office is sending a package to two local clients. One intern is sent to walk over to the building next door and deliver the first package. He enters the building, takes the elevator, and rings the doorbell until the client opens the door and signs for the package. The second intern is sent out on bicycle to deliver that client’s package a block away. When she arrives at the recipient's building, the security guard will not let her in with the bicycle, so the guard signs for the package and delivers it to the recipient. The Law office is pleased that both clients received the packages at nearly the same time.

- Yes
- No
Principle Identification Task - Urinary Text (Experiment 1)

Your final task is to think about the materials you have read today, and consider each the four statements below and judge whether or not the concept or principle exhibited in the statement is related or similar to that presented in “The Urinary System” text.

An experimenter is studying the brain. She has found that the effect of drinking alcohol and caffeine impact the brain even with very low doses, but certain drugs intended to help cure psychological illnesses, like Alzheimer’s, don’t have any impact. She knows that this is because of the blood-brain barrier, where certain types of cells are restricting the passage of solutes, allowing specific chemicals to pass through easily, while others have trouble passing through these barriers, so that the medicine is not delivered to the brain.

- Yes
- No

On Francine’s 30th birthday she noticed a “floater” in her vision. Confused as to why she was seeing them for the first time, she went to the eye doctor concerned. Her eye doctor assured her she was fine, but checked to be sure the retina was not detached. After ensuring her retina had not detached from the tissue, he began to describe the jelly-like fluid in the eyes called vitreous. He told her that as she grows older the fluid thickens causing small particles in her eye to become more visible. The small spots and “floaters” that she sees are harmless and would likely not cause any future vision problems.

- Yes
- No

Fred bought his first used car, but he didn’t know to check all his fluid levels. Shortly after buying it, he took it to the shop because the engine was overheating. The service person noticed that the car’s radiator coolant was low, so she added a gallon of fluid, containing 50% water and 50% antifreeze. With the proper amount of radiator coolant in the car, more heat is carried away from the engine, thus solving the problem of the car overheating.

- Yes
- No

Nick hates the taste of water from the faucet, so he always makes sure to filter his water with a specially designed water pitcher that he keeps in his refrigerator. The pitcher he uses makes the water taste better by removing chlorine and any other larger sediment from the tap water. Smaller compounds such as salts and other minerals pass freely through the filter due to their size. Recently, Nick noticed that when he fills the pitcher to the top, the water flows through the filter faster than when he only fills it part of the way.

- Yes
- No
Inference Verification Technique Measure of Integration (Experiment 1)

You will now be asked to respond to another series of questions about the material you have just read. This time you will be presented with 20 sentences and asked to indicate whether or not you believe the sentence can be reasonably inferred from the biology materials you have read today. In other words, you are asked to determine if each statement would be a logical (true) conclusion based on the information that was presented in the materials, even if it was never explicitly stated.

Mark "Yes" if you believe the statement can be inferred from the materials you have read today. Mark "No" if you believe the statement cannot be inferred from the materials you have read today.

When antidiuretic hormone (ADH) is secreted by the hypothalamus more water will enter the vasa recta and peritubular capillaries.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

While the filtrate is in the collecting duct of the kidney, water can be reabsorbed into the body by passing through water pores, called “aquaporins”, created from the release of antidiuretic hormone (ADH).

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

When the hormone angiotensin II is produced it acts as a powerful vasoconstrictor, thus raising blood pressure and changing the amount of water, salts, waste products, and other small molecules entering Bowman's capsule.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

Transport proteins enable hydrophobic hormones to stay in the blood longer because large proteins like these are not filtered out of the glomerulus, and flow instead into the efferent arteriole.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

High filtrate pressure in Bowman's Capsule pushes filtrate through the nephron and decreases the amount of the enzyme renin secreted by specialized kidney cells.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No
Nutrients, waste, and other chemicals travel through the circulatory system all over the body to the kidneys, stimulating physiological responses in cells a considerable distance apart.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

The hypothalamus regulates primitive functions of the body such as water balance and the final composition of urine.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

Parathyroid hormone increases calcium absorption by acting on the ascending limb of the Loop of Henle, which transports salts, such as calcium, out of the nephron and toward the blood inside the vasa recta.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

The adrenal glands are located in the small of your back just below your ribs.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

Steroids are hydrophobic (water fearing) hormones that must bind to hydrophilic transport proteins to get to their destination, therefore these large protein complexes are not filtered out of the capillaries and into Bowman’s capsule.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

The pituitary gland is roughly the same size as the kidneys.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No
The six hormones that are secreted by the hypothalamus to regulate the anterior pituitary gland regulate the volume and composition of all of your body fluids.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

The Loop of Henle, where water is absorbed back into the blood within the vasa recta, is regulated through the form of negative feedback inhibition.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

The primary way the endocrine system communicates is through the renal artery and renal vein.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

Endocrinology is the study of hormones and how they travel through the blood, passing into small veins, which merge into larger veins, and then drain into the renal vein.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

Blood vessels come into contact with every part of the nephron, allowing water and solutes to pass between the blood and the fluid for cells that have receptors for them.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

In cells of the uterine mucosa, estrogen and its nuclear receptor activate a gene for the protein that functions as the progesterone receptor, containing the solutes needed in a healthy body, particularly water and salts.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No
There are no active transport proteins specific for waste products, such as aldosterone, which is unusual because it binds weakly to albumin, and is left behind in the filtrate of the proximal convoluted tubule.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

Hormones that pass directly into the nucleus of a cell eventually dissolve into the extracellular fluid, providing the solute gradient that drive osmosis out of the descending limb of the Loop of Henle.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

The adrenal cortex surrounds the medulla and produces aldosterone, which acts on the nephrons causing them to reabsorb more ions, drawing water into the body from the filtrate and causing the concentration of the waste molecules to increase.

Can this sentence be reasonably inferred from the biology materials?
- Yes
- No

You have completed this set of questions, please click next to continue to the last part.
Appendix B - Experiment 2

Implied Informed Consent Form (Experiment 2)
Script and PowerPoint Slide (Experiment 2)
Need for Cognition REVISED (Experiment 2/Experiment 3)
Test of Relational Reasoning Sample (Experiment 2)
Combined Text (Experiment 2/Experiment 3)
Principle Identification Technique REVISED Items - Endocrine (Experiment 2/Experiment 3)
Principle Identification Technique REVISED Items - Urinary (Experiment 2/Experiment 3)
Inference Verification Technique Measure REVISED Items (Experiment 2/Experiment 3)
Verbal Free Recall Integration Rubric (Experiment 2/Experiment 3)
Diagram Free Recall Integration Rubric (Experiment 2/Experiment 3)
Implied Informed Consent Form (Experiment 2)

The Pennsylvania State University

Title of Project:  Text Comprehension in Biology
Principal Investigator:  Carla Firetto, Graduate Student
127 Hammond Building
University Park, PA 16802
cmf270@psu.edu

Advisor:  Dr. Peggy Van Meter
368 Frear Building
University Park, PA 16802
pnv1@psu.edu

1. Purpose of the Study: The purpose of this research study is to explore how college students read and understand texts.

2. Procedures to be followed: You will be asked a series of questions about what you know and how you think and then you will be given instructions and asked to read text about biology content and then respond to a series of questions about what you have read.

3. Duration: It will take about two-three hours to complete the entire procedure.

4. Statement of Confidentiality: Your participation in this research is confidential. The researcher would use ID information only to inform the teacher about extra credit. Once this is completed, the ID would be destroyed or stored separately from the data. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared because your name is in no way linked to your responses. Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

5. Right to Ask Questions: Please contact Carla Firetto at cmf270@psu.edu with questions or concerns about this study.

6. Payment for participation: Participants will receive 6 extra credit points for their Biology course for completion of part 1 and 4 points for part 2. There is another option to participating to receive the extra credit. This option is to read an article related to this research and write a 4-5 page paper taking approximately three hours. Please e-mail Carla Firetto at cmf270@psu.edu for more information.

7. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and submission of the survey implies that you have read the information in this form and consent to take part in the research. You will be given a copy of this form for your records or future reference.
Hello, My name is Carla Firetto we are here today for the biology 141 study. Please log on to your computer and open Firefox Browser. I am going to go around and hand you all a sheet of blank paper.

Please put your ID information on the top of the page. This information is used to connect what you put on the page with your responses online. Dr. Waters will not be informed of your responses to any of the questions you answer here today. He is ONLY informed of whether or not you will have earned extra credit. Please do not use the paper until you are told to do so. There is only one question that uses the paper. Do not write on the paper until that point. When you complete that question, please turn the paper over you will not use the paper again.

I am studying how students learn from Biology material, and I am working toward helping college students understand biology text better. Because this study is in Educational Psychology, things may be a little different than you are used to, so you should please read everything carefully. Also because this is a research study, we ask that you do not share the details of anything you have done here today with your classmates until everyone has gotten the chance to participate. Any talking about this study with students who have not participated will impact the results, so please wait until after the last session on Wednesday evening, then you are free to discuss this study as much as you wish.

On the last page of the survey you will indicate whether or not you wish to be contacted for part 2 of the research. Make sure that you indicate your e-mail address as you will be e-mailed the link to the survey. You may complete the survey on your own time until the survey is closed. Part 2 is worth 4 additional extra credit points.

Because this study involves reading, the time that it takes individuals to complete the study will vary by individual. This session is reserved for 2 hours, but the average time for completion is a little under an hour and a half. So please take your time, there is no need to rush. While you are going through the study, please be aware that the back button on your browser will not work. Please do not attempt to use it, or the website will give you a warning error. Finally, please close all other browsers and windows that you may have open. Please make sure you have Facebook and any e-mail closed. Also please make sure your cellphones are silent and put away. Please devote your attention entirely to the survey and avoid any distractions.

When you are ready to begin please go to the link on the slide here. When you open the survey, the first thing you will see is the consent document, once you have completed everything, bring up the white paper and put it in the box and take a copy of the consent form for your records. While you are working through the survey I will be walking around. If you have any questions, I will be happy to answer them, just quietly raise your hand and I will be around.

Bio 141 Research

- Please take a blank sheet of paper
  - Make sure you have a pen/pencil
  - Don't write on it till you are told to
- Please read everything carefully
- Don't share or discuss
- Last page of the survey
  - 6 points earned
  - Possible 4 more (part 2)
- Time duration variation
- No "back" button
- No other windows open
- http://tinyurl.com/biol141study
Need for Cognition REVISED (Experiment 2/Experiment 3)

Indicate your degree of agreement or disagreement with each of the statements below.

You must click EACH slider to enter your response, questions with sliders that are "dim" have not been completed.

Be assured there is NO correct or incorrect response to any of these statements.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Level</th>
<th>Very Strong Disagreement</th>
<th>Moderate Disagreement</th>
<th>Neither Agree nor Disagree</th>
<th>Moderate Agreement</th>
<th>Very Strong Agreement</th>
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<tbody>
<tr>
<td>I would prefer complex to simple problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
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<tr>
<td>I like to have the responsibility of handling a situation that requires a lot of thinking.</td>
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<td>-2</td>
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<td>Thinking is not my idea of fun.</td>
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<tr>
<td>I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.</td>
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<tr>
<td>I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something.</td>
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<tr>
<td>I find satisfaction in deliberating hard and for long hours.</td>
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<tr>
<td>I only think as hard as I have to.</td>
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</table>

Note: Items were unchanged.
Test of Relational Reasoning Sample (Experiment 2)

Instructions:

Students who complete Part 2 will earn 4 points of extra credit for compensation in Biology 141. The focus of Part 2 is on relational reasoning which is an important cognitive process used for learning. In this study you will experience four separate sections that each examine a different form of relational reasoning. You can expect it to take about 45 minutes, but individual times may vary.

- Find a quiet place where you will not be interrupted during the course of this study. Minimize all the distractions around you (turn off music/tv, close other websites/programs, etc).

- Do not discuss this part of the study with classmates until after all students have completed it. (Wednesday, November 28th, 11:59pm)

- Please try to remain focused and do your best when answering the questions.

Click the continue button to move on to the next page. Be sure to read and follow all instructions carefully.
The Urinary System and The Endocrine System

Introduction to the Urinary System
The function of your urinary system is much more than simply producing urine. The urinary system regulates the volume and composition of all of your body fluids: the blood, the cerebral spinal fluid bathing your brain, the interstitial fluid surrounding all of your cells, and the intracellular fluid within those cells. It would be impossible to excrete metabolic waste or maintain a healthy blood pressure, salt balance, and water balance without the urinary system. The principle organs of the urinary system are the kidneys.

All of the fluids in your body connect to one another at some point, usually by coming into direct or indirect contact with the blood. Throughout your body, nutrients and water leave the blood to nourish cells, and waste products diffuse from the cells and enter the blood. Your circulatory system transports nutrients, waste, and other chemicals from all over the body to the kidneys. An average sized person has approximately five quarts of blood, so to regulate the levels of salts and other nutrients, and to prevent waste products from building up throughout the body, every drop of blood is filtered through the kidneys approximately 60 times per day.

Your kidneys are the pair of organs located in the small of your back just below your ribs. Each kidney is about the size of a standard computer mouse. Blood enters and leaves each kidney through a renal artery and renal vein. The kidneys excrete urine, which is composed of metabolic waste products, excess water and salts, and other molecules. The ureters, a pair of narrow tubes, transport urine from the kidneys to the urinary bladder. Urine is stored in the bladder until it is expelled from the body through the urethra, the tube connecting the bladder to the outside world. See Figure 1 for anterior and posterior views of this system.

Introduction to the Endocrine System
If the body is to function as an integrated whole, its organs must communicate with each other and coordinate their activities. Even very simple organisms composed of only a few cells have mechanisms for intercellular communication, suggesting that such mechanisms evolved very early in the history of life. In humans, one such system is the endocrine system, which communicates with chemical messengers called hormones. This text is primarily about the endocrine system of communication, or endocrinology, the study of hormones and how they travel through the blood. It will address both the large-scale components such as the anatomy of the hypothalamus and the pituitary glands and more detailed components of the hormones and how they stimulate and inhibit cells, tissues, and organs. See Figure 2 for a graphic representation of how hormones travel through the circulatory system.
Figure 2: Hormones travel through the circulatory system to stimulate their target cells.

The body has four principle avenues of intercellular communication, but the primary way the endocrine system communicates is through hormones. Hormones, in the strictest sense, are chemical messengers that are transported by the bloodstream and stimulate physiological responses in cells of another tissue or organ, often a considerable distance away. The glands, tissues, and cells that secrete hormones constitute the endocrine system: the study of this system and the diagnosis and treatment of its disorders is called endocrinology.

Organs of the Urinary System
Internally, the kidney is divided into three regions, the renal cortex, medulla, and pelvis. The renal medulla is composed of a series of triangular structures called renal pyramids. Each pyramid ends in a rounded point called a renal papilla. Blood circulates throughout the renal cortex and renal medulla, and this is where the kidney regulates the volume and composition of the fluid, forming urine in the process. The newly formed urine drips from the renal papillae of the renal pyramids and is collected by a series of small funnels (major calyx and minor calyx). These small funnels channel the urine into a large funnel, the renal pelvis, which then passes the urine to the ureter for transport to the bladder. See Figure 3 for a cross section of the kidney depicting these structures.

Figure 3: (a) human and (b) illustrated cross sections of the kidney depicting major structures.

Glands of the Endocrine System
Unlike other systems, there is no master control center that regulates the entire endocrine system, but the pituitary gland and the hypothalamus have a more wide-ranging influence than any other part of the system.

Hypothalamus
The hypothalamus, shaped like a flattened funnel, is at the bottom part of the brain. It regulates primitive functions of the body ranging from water balance and thermoregulation to sex drive and childbirth. Many of its functions are carried out by way of the pituitary gland, which is closely associated with the
The hypothalamus both anatomically and physiologically. Figure 4 illustrates the hypothalamus.

Pituitary Gland
The pituitary gland is suspended from the floor of the hypothalamus by a stalk and housed in a depression of the sphenoid bone. The pituitary gland is roughly the size of a kidney bean, usually about 1.3 cm wide; it grows about 50% larger in pregnancy. The pituitary gland is actually composed of two structures; the anterior pituitary, which constitutes the anterior three-quarters of the pituitary and the posterior pituitary, which constitutes the posterior one-quarter of the pituitary, each has separate functions but they are so closely joined that they look like a single gland. Figure 4 illustrates the anterior and posterior pituitary glands.

Communication between the Hypothalamus and the Pituitary gland
The anterior pituitary has no nervous connection to the hypothalamus but it is linked to the hypothalamus through a complex of blood vessels called the hypophyseal portal system. The hypothalamus controls the anterior pituitary by secreting hormones that enter the hypophyseal portal system, and then enter the anterior pituitary tissue. There are six hormones that are secreted by the hypothalamus to regulate the anterior pituitary gland; these hormones may either stimulate pituitary cells to secrete hormones or inhibit the pituitary hormone secretions to regulate the function of various organs or tissues. For example, Luteinizing hormone (LH) stimulates the ovaries to release an egg (ovulation) in females and growth hormone (GH) stimulates mitosis and widespread bone, liver, and muscle growth.

The posterior pituitary is not technically a true gland but is actually nervous tissue. The nerve fibers arise from certain cell bodies in the hypothalamus, pass down the stalk as a bundle and end in the posterior pituitary. The hypothalamic neurons synthesize hormones and transport them down the axons to the posterior pituitary where they are stored until a nerve signal triggers their release into the blood. Unlike the anterior pituitary, these hormones are synthesized in the hypothalamus and are stored in the pituitary for release on command. For example, antidiuretic hormone (ADH), secreted by the hypothalamus, increases water retention by signaling the cells of the distal convoluted tubule and collecting duct to create aquaporins, thus reducing urine volume and preventing dehydration. In extreme situations, ADH may also cause vasoconstriction throughout the body.
Figure 5: Major glands of the endocrine system

Other Endocrine Glands
The parathyroid glands consist of three or four ovoid glands partially embedded in the posterior surface of the thyroid. The parathyroid glands secrete parathyroid hormone (PTH) in response to hypocalcaemia to raise blood calcium levels. Parathyroid hormone acts on the Loop of Henle in the nephron to increase calcium reabsorption. See Figure 3 for a visual of the parathyroid glands.

The kidneys sit in the posterior part of the abdominal cavity and regulate the volume and composition of body fluids. When filtrate flows slowly through the nephron (due to low blood pressure), specialized kidney cells secrete the enzyme renin, which activates a cascade of hormones throughout the body called the renin-angiotensin system. The hormone angiotensin II is ultimately produced and acts as a powerful vasoconstrictor, thus raising blood pressure. Angiotensin II also stimulates aldosterone and ADH release.

The adrenal glands sit like a cap on the superior surface of each kidney. Like the pituitary gland, they consist of two parts, the adrenal medulla and the adrenal cortex. The adrenal medulla acts both as an endocrine gland and as a ganglion of the sympathetic nervous system. The adrenal cortex surrounds the medulla and produces a number of steroid hormones, such as aldosterone, which acts on the nephrons and causes them to reabsorb more ions, which then draw water, into the body. See Figure 5 for a visual of the adrenal glands.

How the Urinary System Works
Within the renal cortex and medulla, the blood comes into contact with millions of specialized tubes called nephrons. The nephron is the functional unit of the kidneys; it is the nephrons that regulate the volume and composition of the blood passing through the kidney. A nephron is composed of four parts: Bowman’s capsule, the proximal convoluted tubule, the Loop of Henle, and the distal convoluted tubule. Blood vessels come into contact with every part of the nephron and allow water and solutes to pass between the blood and the fluid in the nephron.

Bowman’s Capsule
The blood that entered the kidney through the renal artery is distributed into millions of little arteries. The smallest arteries, called afferent arterioles, bring blood to Bowman’s capsule. The afferent arterioles actually branch out to form a ball of tiny capillaries called the glomerulus. Bowman’s capsule surrounds the glomerulus. The walls of the glomerular capillaries are leaky, and the blood pressure drives water, salts, waste products, and other small hydrophilic molecules out of the capillaries and into Bowman’s capsule. Once inside Bowman’s capsule, the fluid is called filtrate. The filtrate is a mix of water, nutrients needed to remain healthy, and waste products that need to be eliminated. See Figure 6 for an illustration of the nephron, and in particular the peritubular capillaries and the glomerulus.
Figure 6: Illustration of the nephron and peritubular capillaries.

It is important to note that only a small sample of the blood in the glomerulus filters out to become filtrate in Bowman’s capsule. Most of the blood, including large proteins and other molecules, is not filtered at all, and flows instead into the efferent arteriole. The efferent arteriole carries the blood to the peritubular capillaries, which surround the next part of the nephron, the proximal convoluted tubule.

Proximal Convoluted Tubule
The filtrate pressure in Bowman’s capsule, determined by blood pressure, pushes the filtrate into the next region of the nephron, the proximal convoluted tubule. Remember that the filtrate contains both nutrients and waste products. Active transport proteins in the membrane of the proximal convoluted tubule transport nutrients like salts, sugars, and amino acids out of the nephron and toward the blood inside the peritubular capillaries. There are no active transport proteins specific for waste products, so they are left behind in the filtrate of the proximal convoluted tubule. Imagine cleaning your bedroom by throwing everything in your room into the garbage, including your favorite books and posters, along with the scrap paper, food wrappers, and other waste. If you then transported your books and posters back into your bedroom, leaving the waste behind, you would be cleaning your bedroom in a way that is similar to how the nephron cleans the blood. See Figure 7 for a graphic representation of the flow of filtrate through the nephron.
The nutrients that were transported out of the proximal convoluted tubule and entered the peritubular capillaries will flow into the capillaries of the vasa recta next. The filtrate still contains solutes that are needed by a healthy body, especially water and salts. This filtrate flows out of the proximal convoluted tubule and into the next region of the nephron, the Loop of Henle. The vasa recta are the capillaries surrounding the Loop of Henle.

Loop of Henle
Two connecting tubes, a descending limb and an ascending limb, comprise the Loop of Henle. Filtrate leaving the proximal convoluted tubule enters the descending limb of the Loop of Henle, where water is absorbed (via osmosis) back into the blood within the vasa recta. Again, not every drop of water is absorbed back into the blood, just some of it. As the filtrate passes through the descending limb and enters the ascending limb of the Loop of Henle, active transport proteins in the membrane of the ascending limb transport salts (i.e., sodium, calcium, chloride, and potassium) out of the nephron and toward the blood inside the vasa recta. Some of these salts dissolve into the extracellular fluid and provide the solute gradient that drives osmosis out of the descending limb of the Loop of Henle. See figure 8 for more detail regarding absorption and secretion in the nephron.
Water and salts are absorbed into the blood and secreted by the Loop of Henle, and waste products are, for the most part, left behind. The water and salts that have been absorbed eventually pass into the capillaries of the vasa recta. The blood within the vasa recta flows into another set of peritubular capillaries. These capillaries surround the last section of the nephron, the distal convoluted tubule.

Distal Convoluted Tubule

The filtrate remaining in the ascending limb of the Loop of Henle flows into the distal convoluted tubule. At this point, the composition of the filtrate is very different from its composition in Bowman’s capsule. Most of the water, salts, and other nutrients have been absorbed back into the blood stream. As water has left the filtrate, the concentration of the waste molecules has increased. Anything not absorbed back into the blood stream will become part of the urine. The distal convoluted tubule fine tunes the composition of the urine, absorbing ions, nutrients, and water that the body may need and passing them to the blood within the peritubular capillaries. It also transports additional waste products out of the blood and into the distal convoluted tubule for disposal in the urine. See Figure 9 for the absorption of water and salts in the Loop of Henle.
Blood in the peritubular capillaries eventually passes into small veins, which merge into larger veins, and then drain into the renal vein. The renal vein of each kidney carries blood to the inferior vena cava, the large vein that returns blood to the heart. The distal convoluted tubule is the very last part of the nephron. Filtrate in the distal convoluted tubule passes into a larger tube, the collecting duct, where a little more fine tuning is possible before urine is finally formed.

Collecting Duct
Each collecting duct receives filtrate from many nephrons, and transports that filtrate to the papilla of the renal pyramid. Once the filtrate drips out of the collecting duct opening at the papilla, the fluid is called urine and its composition cannot be adjusted anymore. However, while the filtrate is still in the collecting duct, water can be reabsorbed into the body if needed. The water passes out of the collecting duct through water pores, called “aquaporins”, and enters the circulatory system through the vasa recta and peritubular capillaries discussed above.

Summary
Depending on the body’s need, you can excrete large amounts of a very watery urine or you can excrete small amounts of a very concentrated urine. The final composition of your urine depends on how much salt, water, or other substances you need to retain or eliminate to maintain a healthy internal environment. As your blood passes through your kidneys, its composition is changed. As that blood travels to the rest of your body, the blood changes the composition of the other body fluids by gaining or losing water and solutes, and those other body fluids change the composition of the blood as well. When the blood returns to the kidneys, the whole process starts again.

How the Endocrine System Works
Hormones
Most hormones fall into three chemical classes: steroids, peptides, and monoamines. Steroids are synthesized from cholesterol and differ mainly in the four-ringed steroid backbone. Examples of steroid hormones include sex hormones produced by the testes and ovaries (such as estrogens and testosterone) and corticosteroids produced by the adrenal gland (such as aldosterone and cortisol). Peptides are chains of 3 to 200 or more amino acids and are synthesized the same way as any other protein. Examples of peptide hormones include hormones produced by the posterior pituitary (such as antidiuretic hormone and oxytocin) and the kidneys (such as renin and angiotensin). Monoamines are also made from amino acids and include several neurotransmitters (such as dopamine and melatonin). See Figure 10 for the chemical structures of these three hormones.

Figure 10: Chemical structures of (a) steroid, (b) monamine, (c) peptide hormones.

To get to a target cell, a hormone must travel in the blood, which is mostly water. Most of the monoamines and peptides are hydrophilic (water loving), so mixing with the blood plasma presents no problem for them. Steroids, however, are hydrophobic (water fearing) and must bind to hydrophilic transport proteins to get to their destination. The transport proteins are albumins and globulins synthesized by the liver. A hormone attached to a transport protein is called a bound hormone and one that is not attached is an unbound hormone. Only the unbound hormone can leave a blood capillary and get to a target cell. Transport proteins
not only enable hydrophobic hormones to travel in the blood, but also prolong their half-lives. They protect circulating hormones from being broken down by enzymes in the blood plasma and liver, and also prevent them from being filtered out of the blood by the kidneys. Unbound hormones may be broken down or removed from the blood in a few minutes, whereas bound hormones may circulate for hours or weeks. Steroid hormones bind to globulins such as transcortin, the transport protein for cortisol. Aldosterone is unusual, and has no specific transport protein but binds weakly to albumin and others. However, 85% of it remains unbound and, correspondingly, has a half-life of only 20 minutes.

Hormones stimulate only those cells that have receptors for them. The receptors or protein or glycoprotein molecules located on the plasma membrane, in the cytoplasm, or in the nucleus. They act like switches to turn certain metabolic pathways on or off when the hormone binds to them. A target cell usually has a few thousand receptors for a given hormone.

Steroid hormones enter the target cell nucleus and act directly on the genes, changing target cell physiology by activating or inhibiting transcription of the gene for a metabolic enzyme or other protein. Being hydrophobic, they diffuse easily through the phospholipid-cholesterol regions of the plasma membrane. Most of them pass directly into the nucleus. In either case, the receptor associates with the target gene in the nucleus, controlling its transcription. Estrogen and progesterone afford a good example of the action of steroid hormones. In cells of the uterine mucosa, estrogen and its nuclear receptor activate a gene for the protein that functions as the progesterone receptor. See Figure 11 for a depiction of a steroid hormone entering a target cell.

Figure 11: Steroid hormone transport to target cell.

Peptides and monoamines are hydrophilic and cannot penetrate into a target cell, so they must stimulate its physiology indirectly. They bind to the cell surface receptors, which are linked to second messenger systems on the other side of the plasma membrane. The best-known second messenger is cyclic adenosine monophosphate (cAMP). When glucagon binds to the surface of a liver cell, for example, its receptor activates a G protein, which in turn activates adenylate cyclase, the membrane enzyme that produces cAMP. cAMP leads ultimately to the activation of enzymes that hydrolyze glycogen stored in the cell. The general point is that the hydrophilic hormones cannot enter the target cell. Yet by merely “knocking on the door” (binding to a surface receptor) they can initiate a flurry of metabolic activity within the cell. Ultimately these pathways lead to metabolic pathways being switched on or off within the cell. Hormonal effects mediated through surface receptors tend to be relatively quick, because they do not depend on the cell synthesizing new proteins before anything else can happen. See Figure 12 for a depiction of a peptide hormone in comparison to a steroid hormone.
Figure 12: Peptide hormone (hydrophilic hormone) transport to target cell through the second-messenger activation in comparison to steroid hormone (hydrophobic hormone) direct activation.

Feedback from Target Organs
The regulation of other endocrine glands by the pituitary is not simply a system of “command from the top down.” Those target organs also regulate the pituitary and hypothalamus through various feedback loops. Most often this takes the form of negative feedback inhibition—the pituitary stimulates another endocrine gland to secrete its hormone and that hormone feeds back to the pituitary or hypothalamus and inhibits further secretion of the pituitary hormone.
Principle Identification Technique REVISED Items - Endocrine (Experiment 2/Experiment 3)

Shawn was using a potholder in one hand to remove a hot pan from the oven. It started to tip because the pan was fuller than he expected. He instinctively reached with his other hand to prevent the pan from falling. The receptor cells in his skin detected the heat from the pot and generated electrical impulses. The electrical signals traveled through his body along nerves and resulted in communicating to his arm muscles to remove his hand from the hot surface. The electrical signals also caused his the heart to pump blood through the body.

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Compare this scenario to the endocrine system.

A New York City Law office is sending a package to two local clients. One intern is sent to walk over to the building next door and deliver the first package. He enters the building, takes the elevator, and rings the doorbell until the client opens the door and signs for the package. The second intern is sent out on bicycle to deliver that client’s package a block away. When she arrives at the recipient’s building, the security guard will not let her in with the bicycle, so the guard signs for the package and delivers it to the recipient. The Law office is pleased that both clients received the packages at nearly the same time.

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Compare this scenario to the endocrine system.
A junior varsity quarterback was at football practice when he got tackled. During the tackle, his right leg broke when it got caught under another player. He had a compound, tibial-fibular fracture, and torn meniscal cartilage. Because the bone broke through the skin, he had to remain in the hospital for some time due to an infection before his leg could be cast. Unfortunately, even though the bones healed, the boy continued to have swelling ("water on the knee") and pain in his knee. After six months, an x-ray revealed that his meniscus was still torn.

Kori wants to get a pet rat, and she wants to learn more about what it would cost to own one. She went to her pet supply store to talk with a sales worker. He told her she needed to purchase three things: food, a cage, and bedding. Everything else was optional. When she calculated the cost of everything she needed, it would be less than one hundred dollars. Every month she would need to spend about twenty dollars for food and bedding. She decided she could afford to own one, and she left the pet store with food, a cage, bedding, and a new rat.
Principle Identification Technique REVISED Items - Urinary (Experiment 2/Experiment 3)

Fred bought a used car, but he didn’t know how well the previous owner took care of it. Shortly after buying it, he noticed that the car was making an erratic noise. When he took the car to get it fixed, the mechanic immediately checked the serpentine belt. When the mechanic inspected it, he noticed a small tear and told Fred that it was important to replace the belt immediately. Fred spent the next few hours in the waiting room, and when he drove the car home, he was happy that the noise was gone.

An experimenter is studying the brain. She has found that the effect of drinking alcohol and caffeine impact the brain even with very low doses, but certain drugs intended to help cure psychological illnesses, like Alzheimer’s, don’t have any impact. She knows that this is because of the blood-brain barrier, where certain types of cells are restricting the passage of solutes, allowing specific chemicals to pass through easily, while others have trouble passing through these barriers, so that the medicine is not delivered to the brain.
Nick hates the taste of water from the faucet, so he always makes sure to filter his water with a specially designed water pitcher that he keeps in his refrigerator. The pitcher he uses makes the water taste better by removing chlorine and any other larger sediment from the tap water. Smaller compounds such as salts and other minerals pass freely through the filter due to their size. Recently, Nick noticed that when he fills the pitcher to the top, the water flows through the filter faster than when he only fills it part of the way.

Carl had a sore throat for several days, so his mother scheduled a doctor’s appointment for him. In the past year, Carl had tonsillitis six times, so his mother was certain his tonsils were infected again. When they met with Dr. Nelson, he confirmed that it was tonsillitis and suggested that Carl get a tonsillectomy. He explained that this was a minor surgery removing the tonsils. Dr. Nelson believed that the surgery may reduce the number of throat infections Carl would have, and had very little side effects.
Inference Verification Technique Measure REVISED Items (Experiment 2/Experiment 3)

When antidiuretic hormone (ADH) is secreted by the hypothalamus more water will enter the vasa recta and peritubular capillaries.

- True
- False

During the time that the filtrate is in the collecting duct of the kidney, water can pass through “aquaporins,” created from antidiuretic hormone (ADH) release, and be reabsorbed into the body.

- True
- False

While the filtrate is in the collecting duct of the kidney, water can be reabsorbed into the body by constricting “aquaporins,” because of the release of antidiuretic hormone (ADH).

- True
- False

When the hormone angiotensin II is produced it acts as a powerful vasoconstrictor, thus holding blood pressure and the amount of water, salts, waste products, and other small molecules entering Bowman's capsule constant.

- True
- False

Transport proteins enable hydrophobic hormones to stay in the blood longer because large proteins like these are not filtered out of the glomerulus, and flow instead into the efferent arteriole.

- True
- False

Large proteins, like transport proteins, are not filtered out of the glomerulus and flow instead into the efferent arteriole allowing the hydrophobic hormones to stay in the blood longer.

- True
- False

When the filtrate pressure in Bowman's Capsule is high, filtrate is pushed through the nephron and the amount of the enzyme renin secreted by specialized kidney cells is decreased.

- True
- False

Nutrients, waste, and other chemicals travel through the circulatory system all over the body to the kidneys, but do not stimulate physiological responses in cells a considerable distance apart.

- True
- False
The hypothalamus regulates primitive functions of the body such as water balance and the final composition of urine.

- True
- False

The adrenal glands sit like a cap on the superior surface of each kidney in the small of your back just below your ribs.

- True
- False

Water fearing hormones (steroids) are large protein complexes that are not filtered out of the capillaries and into Bowman’s capsule and must bind to hydrophilic transport proteins to get to their destination.

- True
- False

Parathyroid hormone increases calcium absorption by acting on the distal convoluted tubule, which transports salts, such as calcium, out of the nephron and toward the blood inside the vasa recta.

- True
- False

The primary way the endocrine system communicates is through the renal artery and renal vein.

- True
- False

Blood vessels come into contact with every part of the nephron, allowing water and solutes to pass between the blood, which is linked to the second messenger system on the other side of the plasma membrane.

- True
- False

There are no active transport proteins specific for waste products, such as aldosterone, because it binds weakly to albumin, and is left behind in the filtrate of the proximal convoluted tubule.

- True
- False

After hormones pass directly into the nucleus of a cell, the hormones dissolve into the extracellular fluid, and provide the solute gradient that drives osmosis out of the descending limb of the Loop of Henle.

- True
- False
**Verbal Free Recall Integration Rubric (Experiment 2/Experiment 3)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Blank, incomprehensible response, or without content from either texts.</td>
</tr>
<tr>
<td>1</td>
<td>Content from a single system (endocrine or urinary) OR content from both systems separated, either physically (e.g., with line breaks) or semantically (e.g., content only from one system followed by content only from the other system).</td>
</tr>
<tr>
<td>2</td>
<td>Content from both systems without separation between the systems OR any indication of integration. May have provided an introductory sentence discussing both systems, or alternated between information from both systems without drawing any connection or causal relationship between the systems.</td>
</tr>
<tr>
<td>3</td>
<td>Content from both systems integrated on a basic OR deep level. Must include a statement of causal connection, generic or specific.</td>
</tr>
</tbody>
</table>

**Category** | **Example** ("/" indicates an “enter”): |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>I remember that the first text was on the kidney and its parts. The second text was on the endocrine system. I would have remembered more specific stuff but it has been a long day, so I'm really tired and cannot focus on it. I think what makes learning biology easier is if there were more interactive learning tools. I think it's different if you read the way urine is made compared to seeing it in a media clip. That would make it much easier and realistic to learn rather than just memorizing which part goes with which part. [sic]</td>
</tr>
<tr>
<td>1</td>
<td>The urinary system has more than one function of producing urine. It regulates what your body fluids are made of. Your kidneys are as big as a computer mouse. Blood enters and leaves your kidneys, and they release urine. The kidney is split into 3 sections. One of them is made of triangular structures. // The endocrine system is for communication between different cells. Every living organism has some sort of mechanism that allows cells to communicate with each other. [sic]</td>
</tr>
<tr>
<td>2</td>
<td>Steroids include hormones like sex hormones including estrogen and testosterone. / The urinary system is vital in keeping our body's waste regulated. / The kidneys are located on your lower back after the spinal cord. / Your blood is constantly being circulated and cleansed through the urinary system. / Wastes enter the bloodstream when cells excrete their waste. / Each hormone has a different cell structure. / Blood enters the kidneys through the renal artery. / Urine is excreted through the urethra. / The urinary system does more than make urine. [sic]</td>
</tr>
<tr>
<td>3</td>
<td>The kidneys are a major part of the urinary system. You have two kidneys each located in your back. Every last drop of blood you have gets filtered through the kidneys every single day. The hypothalamus helps to regulate the amount of ADH (anti diuretic hormone) in your blood stream which either increases or decreases depending on how much water is in your bloodstream which is flowing though your kidneys. Depending on how much water is in your system you will either urinate a large diluted amount or a small concentrated amount. // The endocrine system excretes either steroids, peptides, or monomines. Steroids are hydrophobic which means water fearing and they have to combine to either peptides or monomines, which are hydrophilic, in order to move throughout the body. [sic]</td>
</tr>
</tbody>
</table>
### Drawing Free Recall Integration Rubric (Experiment 2/Experiment 3)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Blank or illegible scribble.</td>
</tr>
<tr>
<td>1</td>
<td>One or more drawings from only a single system (either endocrine or urinary) OR drawings from both systems separated, either physically (e.g., with a line drawn between them) or semantically (e.g., headings or labels above the drawings indicating which system the drawings were from).</td>
</tr>
<tr>
<td>2</td>
<td>One or more drawings from both systems without attempt to draw a separation between drawings from different systems OR an attempt to integrate or connect between systems.</td>
</tr>
<tr>
<td>3</td>
<td>One or more drawings from both systems integrated on a basic or advanced level; multiple systems within the same drawing, explicit connection is not required.</td>
</tr>
</tbody>
</table>

**Examples:**

1. Line separating top and bottom with label for “text 1” and “text 2”.
2. Separate Endocrine and Urinary drawings on page without connections/separations.
3. Upper-right corner drawing has single human figure with “brain”, “pituitary”, “kidney”, & “bladder”. 

(1) Line separating top and bottom with label for “text 1” and “text 2”.
(2) Separate Endocrine and Urinary drawings on page without connections/separations.
(3) Upper-right corner drawing has single human figure with “brain”, “pituitary”, “kidney”, & “bladder”.
Appendix C - Experiment 3

Implied Informed Consent (Experiment 3a)
Script for Sessions (Experiment 3a)
Inspiring Integration Worksheet (Experiment 3a and 3b)
Coaching Comprehension Worksheet (Experiment 3a and 3b)
Control Task Worksheet (Experiment 3a and 3b)
ISSI Items (Experiment 3)
ISSI Factor Loadings (Experiment 3a)
Implied Informed Consent (Experiment 3b)
Script for sessions (Experiment 3b)
ISSI Factor Loadings (Experiment 3b)
Implied Informed Consent Form (Experiment 3a)

Principal Investigator: Carla Firetto, Graduate Student
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pnv1@psu.edu

Other Investigator(s): Chelsea Cameron, cec5144@psu.edu

1. Purpose of the Study: The purpose of this research study is to explore how college students read and understand text.

2. Procedures to be followed: (1) You will be asked a series of questions about what you know and how you think. (2) You will be given instructions and then read about biology while completing a worksheet. (3) You will respond to a series of questions about what you have read.

3. Duration: It will take about two hours to complete the entire procedure.

4. Statement of Confidentiality: Your participation in this research is confidential. The researcher would use ID information only to inform the teacher about extra credit and to connect your responses to other course information should you consent to allow the researchers access to that data on the signed consent document provided on ANGEL. Once this is completed, the ID will be destroyed or stored separately from the data. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

5. Right to Ask Questions: Please contact Carla Firetto at cmf270@psu.edu with questions or concerns about this study.

6. Payment for participation: Participants will receive 5 extra points toward their clicker scores for their Biology 141 course for participation in the research. There is another option to participating to receive the extra credit. This option is to read an article related to this research and write a 4-5 page paper taking approximately two hours. Please e-mail Carla Firetto at cmf270@psu.edu for more information.

7. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and submission of the survey implies that you have read the information in this form and consent to take part in the research.
Script for Sessions (Experiment 3a)

Hello, my name is __________ we are here today for the biology 141 study. The study you are about to participate in is my dissertation study I am completing my Ph.D. in Educational Psychology, and I study how students learn from Biology material. I am working toward developing methods to help college students improve their learning. During the study today, you will use a worksheet that has been developed specifically for the material you will read. We will use your responses to understand about students learn while reading. One of the biggest benefits for you in participating in this study is that the information you will be studying here is covered in the unit you are going to begin next week. We believe that studying from these materials may help improve your understanding of these important concepts. Dr. Malcos will also be asking similar questions on this content as part of her clicker questions, so studying this material may help you to answer these questions. Even though this research is part of Dr. Malco’s class, Dr. Malcos will not be informed of your responses to any of the questions you answer here today. She is ONLY informed of whether or not you will have earned extra credit. Your responses are ONLY used for my research to understand more about how students learn from biology material.

Because this is a research study, we ask that you do not share the details of anything you have done here today with your classmates until everyone has gotten the chance to participate. Any talking about this study with students who have not participated will impact the results, so please wait until after the last session on Wednesday evening, then you are free to discuss this study as much as you wish. Also, because this study is in Educational Psychology, things may be a little different than you are used to, so you should please read everything carefully. The website will walk you through everything you need to do.

Because this study involves reading, the time that it takes individuals to complete the study will vary by individual. This session is reserved for 2 hours, but the average time for completion is about an hour and a half. So please take your time, there is no need to rush. While you are going through the study, please be aware that the back button on your browser and your mouse will not work. There may be places where there is a back button on the bottom of the website, and you are welcome to use it when it is available. If you do accidentally click the back browser button you will see an error and have to refresh the page. Before you begin, please close all other browsers and windows that you may have open. Please make sure you have Facebook and any e-mail closed and that cellphones are silent and put away. Please devote your attention entirely to the survey and avoid any distractions.

I will be handing you a folder, please do not open it yet. In the folder are 3 pieces of paper: two worksheets and blank sheet of paper. You will use the FIRST sheet while you are reading the text. This is the worksheet with the number 1 highlighted on the top (see here). You can also see that your study ID is on the upper right hand corner. Once you finish reading the text you will do a second worksheet. The second worksheet is stapled behind the blank sheet of paper. When you are done reading you will be told to pull out the stapled set of papers and gently separate the second worksheet from the blank page. Be careful not to rip the blank sheet. The blank sheet will be used last. Do not write on it until you are told to. I know this is a lot to remember, the website will walk you through WHEN to use the worksheets in the folder.

Now make sure you open Firefox Browser. You must open FIREFOX. If you cannot find Firefox, please let me know and I will help you. When you are ready to begin please go to the link on the slide here. When you are asked for your study ID, please open the folder to find your ID number stamped on the top of the paper. You will open your folder to find that number, but leave the worksheets in your folder. Once you have worked your way through the entire study, bring up the folder and put it on the table. While you are working through the survey I will be walking around. If you have any questions, I will be happy to answer them, just quietly raise your hand and I will be around.
1) **Select** important content and *paraphrase* it into the boxes below to *organize* the information.

<table>
<thead>
<tr>
<th>Identify and describe the structures of the system.</th>
<th>Urinary System</th>
<th>Endocrine System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the purpose of the system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explain how the structures work together to achieve the purpose.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Describe how the body remains in homeostasis.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2) Use your notes to create *associations* between related ideas from the material. Think of this as if the information you learned are pieces of a puzzle, and your goal is to assemble one large puzzle.

a. How does the Endocrine System influence the Urinary System?

b. How does the Urinary System influence the Endocrine System?

c. Can you generate any other associations?

3) Do you recall the instructions you read at the very beginning of the study? You were asked to integrate and connect between the Endocrine and Urinary Systems.

a. Generate one question that you think might be asked later in the study that tests whether or not you were able to accomplish integrating the two systems.

b. Reflect on whether or not you have studied the materials to integrate between these concepts. Look back at your notes if necessary.
1) Please use the provided outline below to take notes about the Endocrine System.

<table>
<thead>
<tr>
<th>Identify and describe the structures of the system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the purpose of the system.</td>
</tr>
<tr>
<td>Explain how the structures work together to achieve the purpose.</td>
</tr>
<tr>
<td>Describe how the body remains in homeostasis.</td>
</tr>
</tbody>
</table>

(TURN PAGE OVER)
1) Please use the provided outline below to take notes about the Urinary System.

<table>
<thead>
<tr>
<th>Identify and describe the structures of the system.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Define the purpose of the system.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Explain how the structures work together to achieve the purpose.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Describe how the body remains in homeostasis.</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
2) Respond to the following:
   a. Endocrine System:
      i. Describe how monoamines transport to a target cell.
      ii. Describe the appearance of the pituitary gland.

   b. Urinary System:
      i. What is Bowman’s capsule?
      ii. How much, and how concentrated, is the urine that is produced by the kidneys?

3) Do you recall the instructions you read at the very beginning of the study? You were asked to comprehend the material.
   a. Generate one question that you think might be asked later in the study that tests whether or not you were able to accomplish comprehending.
   b. Reflect on whether or not you have studied the materials to comprehend. Look back your notes if necessary.
1) Please use the outline below to take notes about the Endocrine System.

<table>
<thead>
<tr>
<th>Section</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to the Endocrine System</td>
<td></td>
</tr>
<tr>
<td>Glands of the Endocrine System</td>
<td></td>
</tr>
<tr>
<td>How the Endocrine System Works</td>
<td></td>
</tr>
</tbody>
</table>

(TURN PAGE OVER)
1) Please use the outline below to take notes about the Urinary System.

<table>
<thead>
<tr>
<th>Introduction to the Urinary System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organs of the Urinary System</td>
</tr>
<tr>
<td>How the Urinary System Works</td>
</tr>
</tbody>
</table>

(TURN PAGE OVER)
2) Consider the Urinary System
What was the most important piece of information from “Introduction to the Urinary System”?  

What was the most important piece of information from “Glands of the Urinary System”?  

What was the most important piece of information from “How the Urinary System Works”?  

3) Consider the Endocrine System
What was the most important piece of information from “Introduction to the Endocrine System”?  

What was the most important piece of information from “Glands of the Endocrine System”?  

What was the most important piece of information from “How the Endocrine System Works”?  

### ISSI Items (Experiment 3)

<table>
<thead>
<tr>
<th>Integration Items</th>
<th>Separation Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1-Int.</strong> I tried to identify facts about how the endocrine and urinary systems work together.</td>
<td><strong>1-Acc.</strong> I tried to identify facts about the endocrine system and facts about the urinary system.</td>
</tr>
<tr>
<td><strong>2-Int.</strong> I tried to remember facts that applied to both the endocrine system and the urinary system.</td>
<td><strong>2-Acc.</strong> I tried to remember facts about the endocrine system and facts about the urinary system.*</td>
</tr>
<tr>
<td><strong>3-Int.</strong> I tried to consider the connection between the endocrine and the urinary system.*</td>
<td><strong>3-Acc.</strong> I tried to consider only one system at a time.</td>
</tr>
<tr>
<td><strong>4-Int.</strong> I tried to note how the endocrine system and the urinary system are different from one another.*</td>
<td><strong>4-Acc.</strong> I tried to note how the endocrine system has different parts and how the urinary system has different parts.</td>
</tr>
<tr>
<td><strong>5-Int.</strong> I tried to understand how the endocrine system and the urinary system influence each other.*</td>
<td><strong>5-Acc.</strong> I tried to understand about biology by thinking about the information from the endocrine system separately from the urinary system.</td>
</tr>
<tr>
<td><strong>6-Int.</strong> I tried to generate a single summary from the content of both the endocrine system and the urinary system.*</td>
<td><strong>6-Acc.</strong> I tried to generate a separate summary for the endocrine system and the urinary system.</td>
</tr>
<tr>
<td><strong>7-Int.</strong> I tried to form a complete picture of the how the endocrine system and the urinary system work together to influence how the human body functions.*</td>
<td><strong>7-Acc.</strong> I tried to form a picture of how the endocrine system influences how the human body functions separately from how the urinary system influences how the human body functions.</td>
</tr>
<tr>
<td><strong>8-Int.</strong> I tried to understand about biology by comparing the content of the endocrine system and the urinary system.</td>
<td><strong>8-Acc.</strong> I tried to understand how the parts of the endocrine system influence each other and how the parts of the urinary system influence each other.</td>
</tr>
</tbody>
</table>

*Item modified from MTSI.
### ISSI Factor Loadings (Experiment 3a)

**Extraction Sums of Squared Loadings: 47.196% Cumulative**

<table>
<thead>
<tr>
<th>Integration Factor</th>
<th>Integration Items</th>
<th>Separation Factor</th>
<th>Separation Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.828</td>
<td>I tried to identify facts about how the endocrine and urinary systems work together.</td>
<td>.744</td>
<td>I tried to identify facts about the endocrine system and facts about the urinary system.</td>
</tr>
<tr>
<td>.610</td>
<td>I tried to remember facts that applied to both the endocrine system and the urinary system.</td>
<td>.804</td>
<td>I tried to remember facts about the endocrine system and facts about the urinary system.</td>
</tr>
<tr>
<td>.850</td>
<td>I tried to consider the connection between the endocrine and the urinary system.</td>
<td>.435</td>
<td>I tried to consider only one system at a time.</td>
</tr>
<tr>
<td>*</td>
<td>I tried to note how the endocrine system and the urinary system are different from one another.</td>
<td>.648</td>
<td>I tried to note how the endocrine system has different parts and how the urinary system has different parts.</td>
</tr>
<tr>
<td>.609</td>
<td>I tried to understand how the endocrine system and the urinary system influence each other.</td>
<td>.469</td>
<td>I tried to understand about biology by thinking about the information from the endocrine system separately from the urinary system.</td>
</tr>
<tr>
<td>.359</td>
<td>I tried to generate a single summary from the content of both the endocrine system and the urinary system.</td>
<td>.579</td>
<td>I tried to generate a separate summary for the endocrine system and the urinary system.</td>
</tr>
<tr>
<td>.609</td>
<td>I tried to form a complete picture of the how the endocrine system and the urinary system work together to influence how the human body functions.</td>
<td>*</td>
<td>I tried to form a picture of how the endocrine system influences how the human body functions separately from how the urinary system influences how the human body functions.</td>
</tr>
<tr>
<td>.800</td>
<td>I tried to understand about biology by comparing the content of the endocrine system and the urinary system.</td>
<td>*</td>
<td>I tried to understand how the parts of the endocrine system influence each other and how the parts of the urinary system influence each other.</td>
</tr>
</tbody>
</table>

*Item removed from factor analysis.*
Implied Informed Consent Form (Experiment 3b)

Principal Investigator: Carla Firetto, Graduate Student
University Park, PA 16802
cmf270@psu.edu

Advisor: Dr. Peggy Van Meter
363 Frear Building
University Park, PA 16802
pnv1@psu.edu

Other Investigator(s): Chelsea Cameron, cec5144@psu.edu

1. Purpose of the Study: The purpose of this research study is to explore how college students read and understand text.

2. Procedures to be followed: (1) You will be asked a series of questions about what you know and how you think. (2) You will be given instructions and then read about biology while completing a worksheet. (3) You will respond to a series of questions about what you have read.

3. Duration: It will take about two hours to complete the entire procedure.

4. Statement of Confidentiality: Your participation in this research is confidential. The researcher would use ID information only to inform the teacher about extra credit and to connect your responses to other course information should you consent to allow the researchers access to that data on the signed consent document provided on ANGEL. Once this is completed, the ID will be destroyed or stored separately from the data. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

5. Right to Ask Questions: Please contact Carla Firetto at cmf270@psu.edu with questions or concerns about this study.

6. Payment for participation: Participants will receive 15 extra points for their Biology 240 course for participation in the research. There is another option to participating to receive the extra credit. This option is to read an article related to this research and write a 4-5 page paper taking approximately two hours. Please e-mail Carla Firetto at cmf270@psu.edu for more information.

7. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and submission of the survey implies that you have read the information in this form and consent to take part in the research.
Script for Sessions (Experiment 3b)

Hello, my name is _________ we are here today for the biology 240 study. The study you are about to participate in is my dissertation study I am completing my Ph.D. in Educational Psychology, and I study how students learn from Biology material. I am working toward developing methods to help college students improve their learning. During the study today, you will use a worksheet that has been developed specifically for the material you will read. We will use your responses to understand about students learn while reading. One of the biggest benefits for you in participating in this study is that the information you will be studying here is covered in the unit you are going to begin next week. We believe that studying from these materials may help improve your understanding of these important concepts. Even though this research is part of Dr. Waters’s class, Dr. Waters will not be informed of your responses to any of the questions you answer here today. He is ONLY informed of whether or not you will have earned extra credit. Your responses are ONLY used for my research to understand more about how students learn from biology material.

Because this is a research study, we ask that you do not share the details of anything you have done here today with you classmates until everyone has gotten the chance to participate. Any talking about this study with students who have not participated will impact the results, so please wait until after the last session on Wednesday evening, then you are free to discuss this study as much as you wish. Also, because this study is in Educational Psychology, things may be a little different than you are used to, so you should please read everything carefully. The website will walk you through everything you need to do.

Because this study involves reading, the time that it takes individuals to complete the study will vary by individual. This session is reserved for 2 hours, but the average time for completion is about an hour and a half. So please take your time, there is no need to rush. While you are going through the study, please be aware that the back button on your browser and your mouse will not work. There may be places where there is a back button on the bottom of the website, and you are welcome to use it when it is available. If you do accidentally click the back browser button you will see an error and have to refresh the page. Before you begin, please close all other browsers and windows that you may have open. Please make sure you have Facebook and any e-mail closed and that cellphones are silent and put away. Please devote your attention entirely to the survey and avoid any distractions.

I will be handing you a folder, please do not open it yet. In the folder are 3 pieces of paper: two worksheets and blank sheet of paper. You will use the FIRST sheet while you are reading the text. This is the worksheet with the number 1 highlighted on the top (see here). You can also see that your study ID is on the upper right hand corner. Once you finish reading the text you will do a second worksheet. The second worksheet is stapled behind the blank sheet of paper. When you are done reading you will be told to pull out the stapled set of papers and gently separate the second worksheet from the blank page. Be careful not to rip the blank sheet. The blank sheet will be used last. Do not write on it until you are told to. I know this is a lot to remember, the website will walk you through WHEN to use the worksheets in the folder.

Now make sure you open Firefox Browser. You must open FIREFOX. If you cannot find Firefox, please let me know and I will help you. When you are ready to begin please go to the link on the slide here. When you are asked for your study ID, please open the folder to find your ID number stamped on the top of the paper. You will open your folder to find that number, but leave the worksheets in your folder. Once you have worked your way through the entire study, bring up the folder and put it on the table. While you are working through the survey I will be walking around. If you have any questions, I will be happy to answer them, just quietly raise your hand and I will be around.
ISSI Factor Loadings (Experiment 3b)

Extraction Sums of Squared Loadings: 45.846% Cumulative

<table>
<thead>
<tr>
<th>Integration Factor</th>
<th>Integration Items</th>
<th>Separation Factor</th>
<th>Separation Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.827</td>
<td>I tried to identify facts about how the endocrine and urinary systems work together.</td>
<td>.573</td>
<td>I tried to identify facts about the endocrine system and facts about the urinary system.</td>
</tr>
<tr>
<td>.638</td>
<td>I tried to remember facts that applied to both the endocrine system and the urinary system.</td>
<td>.588</td>
<td>I tried to remember facts about the endocrine system and facts about the urinary system.</td>
</tr>
<tr>
<td>.883</td>
<td>I tried to consider the connection between the endocrine and the urinary system.</td>
<td>.510</td>
<td>I tried to consider only one system at a time.</td>
</tr>
<tr>
<td>*</td>
<td>I tried to note how the endocrine system and the urinary system are different from one another.</td>
<td>.642</td>
<td>I tried to note how the endocrine system has different parts and how the urinary system has different parts.</td>
</tr>
<tr>
<td>.688</td>
<td>I tried to understand how the endocrine system and the urinary system influence each other.</td>
<td>.615</td>
<td>I tried to understand about biology by thinking about the information from the endocrine system separately from the urinary system.</td>
</tr>
<tr>
<td>.418</td>
<td>I tried to generate a single summary from the content of both the endocrine system and the urinary system.</td>
<td>.580</td>
<td>I tried to generate a separate summary for the endocrine system and the urinary system.</td>
</tr>
<tr>
<td>.635</td>
<td>I tried to form a complete picture of the how the endocrine system and the urinary system work together to influence how the human body functions.</td>
<td>*</td>
<td>I tried to form a picture of how the endocrine system influences how the human body functions separately from how the urinary system influences how the human body functions.</td>
</tr>
<tr>
<td>.840</td>
<td>I tried to understand about biology by comparing the content of the endocrine system and the urinary system.</td>
<td>*</td>
<td>I tried to understand how the parts of the endocrine system influence each other and how the parts of the urinary system influence each other.</td>
</tr>
</tbody>
</table>

*Item removed from factor analysis.
Footnote

1 It is important to be clear that the reliability of scores from the SVT, IVT, and PIT measures is unacceptably low. Follow-up analysis in both Experiment 1 and Experiment 2 assessed the reliability of scores for only the subsample of participants who had correctly reported knowledge of the instructions. From this analysis, there is no evidence that reliability of scores improved when only including the subsamples of participants who attended more closely to the respective condition instructions. Because of the low reliability of scores from these measures, it is not acceptable to generalize the results from these measures beyond the sample of participants recruited in these experiments. Furthermore in the interpretation of these results, emphasis should be placed on inspection of the effect sizes. See the limitations section of Chapter 5 for more information.
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**Education**

**M.S. Educational Psychology**, 2007, The Pennsylvania State University, University Park, PA  
Thesis: Intertextuality: A study of readers with multiple texts

**B.A. Psychology/Sociology**, 2005, Thiel College, Greenville, PA  
Honors: valedictorian, dean’s key, summa cum laude

**Research, Teaching, and Service Experiences**

Research Assistant - Improving Students' Problem-Solving Abilities in Thermodynamics, NSF TUES.


Adjunct Faculty - Department of Education, Bucknell University.

Course Instructor - The Pennsylvania State University.

Graduate Student Peer Mentor/Tutor - POSSE Leadership Grant.

College of Education Diversity and Community Enhancement Committee (DCEC), PSU.

**Selected Presentations & Publications**

*Journal of Educational Psychology.*


