THE PRETESTING EFFECT: HOW QUESTION-TYPE AND STRUCTURE BUILDING ABILITY IMPACT LEARNING

BY

KYLE JAMISON ST. HILAIRE

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Approved By:

Janine M. Jennings, Ph.D., Advisor

Eric R. Stone, Ph.D., Chair

Shana K. Carpenter, Ph.D.

Wayne E. Pratt, Ph.D.

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ABSTRACT

Recent research shows that answering pre-study test questions can enhance learning (the pretesting effect). However, most of the pretesting literature has only examined the learning benefits of asking closed-ended pretest questions (i.e., fill-in-the-blank). Whereas learning benefits have been found for "old" questions asked at both pretest and posttest (intentional learning), no learning benefits have been found for "new" questions only asked at posttest (incidental learning). The present study was designed to: a) replicate previous work in showing intentional learning with closed-ended pretest questions; b) extend the pretesting effect by seeing if open-ended pretest questions (i.e., short answer) can produce intentional *and* incidental learning; and c) determine if the pretesting effect may be influenced by individual differences in structure building ability. Participants first either took a pretest consisting of closed- or open-ended questions then studied a prose passage or simply studied the passage (no pretest), after which a closed- or open-ended posttest was administered. They then carried out the Multi-Media Comprehension Battery (Gernsbacher & Varner, 1988) to measure structure building ability. Answering closed-ended pretest questions only enhanced intentional learning, as expected. However, open-ended pretest questions showed transfer, enhancing intentional and incidental learning at posttest. The relationship between structure building ability, the pretesting effect, and question-type (open vs. closed-ended) did not prove to be significant, perhaps due to low statistical power but the data suggest that follow-up work could be worthwhile.

INTRODUCTION

A goal of educational practice is to enhance teaching and learning strategies in the classroom to better facilitate student learning. Although many of these strategies have examined how students study and encode to-be-learned material, recent efforts have examined the potential learning benefits of test-taking. Tests are most often administered in the classroom to diagnostically assess how much information students have learned; however, recent research shows that test-taking also achieves a second purpose. Tests can be learning events in themselves where the act of retrieving information can strengthen one's memory for that information more effectively than study alone. This phenomenon has been named the testing effect, and was illustrated in a series of experiments by Roediger and Karpicke (2006), in which they compared the amount of learning that took place after students either: a) sequentially studied a prose passage four times (SSSS); or b) studied the passage once, then spent the subsequent three intervals being tested on the prose passage material (STTT). The researchers found that SSSS led to significantly greater scores on an immediate retention test when compared to STTT, but more importantly, the findings were reversed when the retention test was delayed for one week. Even though STTT participants only studied the prose passage once, they were able to recall significantly more details from the prose passage on a delayed retention test relative to participants who studied the passage four times (SSSS). This research provides evidence that testing enhances learning better than does simply studying, specifically over longer retention intervals.

Similar to early views of the value of tests that follow study (i.e., posttests), perceptions of tests that precede study (i.e., pretests) have typically involved little regard

for whether they, too, may enhance learning. Rather, pretests have generally been seen to serve two purposes. First, pretests are often used to establish how much knowledge a person has at baseline to determine the amount of learning that occurs as the result of practice, teaching, or training. Thus, pretests can provide an objective measure of improvement over time. Second, pretests can be used predictively. For example, the more knowledge a person has at baseline, as shown by greater performance on a pretest, the better his or her outcomes are predicted to be at posttest (Grover, Heck, & Heck, 2009). However, as Roediger and Karpicke (2006) discovered with post-study tests, pretests may do more: they may also serve as learning events that enhance knowledge acquisition.

The Pretesting Effect

The learning benefits provided by answering pretest questions was examined in an influential study carried out by Richland, Kornell, and Kao (2009). Across a series of experiments, they manipulated whether subjects received a pretest or not before studying a short prose passage. In this paradigm, half of the participants were assigned to a study-only condition and given 10 minutes to study the passage, and the other half were assigned to a pretest-and-study condition, spending the first two minutes guessing the answers to pretest questions followed by eight minutes of study. Neither feedback nor correct answers were provided as part of the pretesting phase. Immediately after the study session, all participants were asked to complete a posttest comprised of questions taken directly from the study passage. The posttest questions consisted of both previously-seen pretest questions (i.e., old questions) and new questions not asked at pretest. Therefore, half of the questions were old and half were new for pretest-and-study participants while all of the questions were new for the study-only participants.

Richland and her colleagues (2009) hypothesized that being pretested on the study materials would enhance learning to a greater degree than would extra study time. They suggested that, similar to the testing effect literature, attempts at retrieval could enhance learning. By trying to generate plausible guesses in response to the pretest questions, it was thought that the retrieval route between each question and its answer would be strengthened in a manner that would augment learning for both the tested and non-tested information during subsequent study. Further, these benefits would occur regardless of whether or not a pretest guess was correct, suggesting it is the *attempts* at retrieval that are important. However, their hypothesis was only partially supported. For example, in their first experiment, although pretest-and-study participants did significantly better on previously-seen (i.e., old) questions (75%) than study-only participants did (56%), they enjoyed no benefit on the new, previously-unseen questions at posttest (50%). This research suggests that pretests enhance learning, but only for items that were pretested; there is no benefit at posttest for information that was not assessed at pretest.

These findings were corroborated across two subsequent experiments in which Richland et al. (2009, Experiments 2 & 3) used the same pretesting paradigm with slightly altered study materials to further understand the pretesting effect. In particular, they wanted to rule out the possibility that the pretesting effect may have arisen not from attempts at retrieving information but because answering pretest questions may have selectively directed participants' attention to the pretested content during later study. It was thought that this directed attention would make pretest participants' study efforts more focused and efficient relative to those of the study-only participants. Consequently, they conducted two experiments trying to equate for attentional differences during study

to mitigate possible attention-related advantages enjoyed by the pretested participants. To do so, the researchers modified the study passage to draw attention to all of the to-be-tested information regardless of the participants' experimental condition (i.e., pretest-and-study vs. study-only). Each of the to-be-tested sentences in the study passage was italicized (Experiment 2) or bolded (Experiment 3), so that any enhanced performance from the pretest relative to study-only should be due to the retrieval attempts associated with the pretest itself, rather than attentional differences directed at the pretested material. If a pretesting effect was still found after attention to the studied material was controlled across groups, this would suggest that engaging with the questions themselves provides more of a benefit than does an increase in attentional focus. This is, in fact, what the researchers found. Emphasizing the to-be-tested information during the study phase provided no reliable, significant benefits for the study-only group relative to the pretest-and-study condition. Instead, the results closely mimicked those of the first study. Richland et al. again found an item-specific pretesting effect such that participants in the pretest-and-study condition performed significantly better on previously-seen questions during the posttest than study-only participants did on those same questions. However, pretested participants did no better on new, previously-unseen questions at posttest when compared to the study-only participants. These experiments provide converging evidence that there is something about being pretested that enhances learning, which, as mentioned, perhaps involves the retrieval attempts themselves. Moreover, they opened the door to a body of research aimed at exploring the nature of this pretesting effect to better understand the learning benefits that answering pretest questions may afford.

Using the pretesting paradigm established by Richland et al. (2009), more recent research has been aimed at replicating their findings with different types of study materials to establish the pervasiveness of the pretesting effect. For instance, one study by Kornell (2014) examined whether pretesting benefits may extend to the learning of trivia facts. As in the original pretesting paradigm, participants were asked to guess the answers to a subset of the trivia facts before studying them (pretest), and for the non-pretested, study-only facts, were provided with extra study time. The researchers found that participants performed significantly better on the pretest-and-study trivia facts than the study-only facts. This research corroborated Richland et al. (2009)'s work, suggesting that the advantages of a pretest outweigh the benefits of extra study time. Similar benefits of a pretest relative to study-only have also been found for learning foreign language vocabulary (Potts & Shanks, 2014), as well as new mathematical concepts (Kapur, 2014). In summary, the pretesting literature converges upon the idea that a pretesting effect does exist, and that it extends across different types of study materials. However, what is still unclear is how pretests function to enhance learning.

Mechanisms behind pretesting effects. To maximize pretesting effects, one needs to understand how they may be operating. Using the pretesting paradigm introduced by Richland et al. (2009), Kornell, Hays, and Bjork (2009) sought to replicate the pretesting effect with simpler study materials that they thought would be more suitable for testing underlying mechanisms. More specifically, they used complete (i.e., tide—beach) and incomplete word pairs (i.e., tide—???) as their study and test materials, and chose word pairs with a pre-existing associative strength of 5%, meaning that when presented with the cue word alone (i.e., tide), participants would correctly produce the

correct target word (i.e., beach) only 5% of the time. These weakly-associated word pairs were meant to mimic Richland and colleagues' (2009) question-and-answer design in that participants would likely be unable to provide the correct target word from a pair when given the cue alone, just as participants would be unable to answer a pretest question before studying a prose passage. However, seeing the complete pair at study should be sufficient to associate the cue words with the targets, just as reading the prose passage would provide the answers to the test questions.

In a series of experiments, Kornell et al. (2009) compared the amount of learning that took place when word pairs were either pretested or not before being studied. All participants in the experiment completed both pretesting and study-only trials to examine within-subjects learning differences. During pretest trials, subjects were presented with an incomplete word pair and instructed to guess the target word. The correct target words were then presented immediately after each pretest trial so that they could be studied. On study trials, each cue and correct target word were presented together for an "extended" study interval equaling the amount of time allotted for the pretest-and-study trials. Participants were told that there would be a memory test at the end of the experiment assessing their recall of the target words when provided with the cues.

As was observed by Richland and her colleagues (2009), Kornell et al. (2009) found evidence in favor of a pretesting effect. For example, in Experiment 4, participants' posttest performance was significantly enhanced for word pairs that were pretested (67%) than those that were simply studied (55%). Of greater interest from these studies though, is that whether subjects made incorrect guesses at pretest (errors of commission) or left pretest answers blank (errors of omission) had no effect on posttest performance.

Moreover, in conjunction with the research presented by Richland et al. (2009), this study provides evidence that a pretesting effect exists regardless of whether study materials are as simple as word pairs or more complex such as prose passages.

Based on their results, Kornell et al. (2009) proposed three potential theories for how pretesting may enhance learning. The first theory suggests that taking a pretest activates a person's semantic network for information related to the pretest questions. Exposure to the pretest itself encourages free-associative thinking about the material before studying it, facilitating later study. For example, being asked to complete the word pair, tide—???, might simultaneously get a person to think about family vacations at the beach while remembering that the oceans' tides are strongly associated with the cycles of the moon. Thus, thoughts related to the cue word, tide, may encourage a person to guess the word, ocean, as being the best exemplar to complete the word pair, since their semantic network activated thoughts about the beach, the ocean, and tides. As thoughts related to the cue may be primed during the pretest, the researchers proposed that activating this semantic network promotes deeper processing of the study materials. Thus, when the correct target word, beach, is provided during a subsequent learning phase, many memory traces related to the cue have already been activated and learning is enhanced.

Kornell and colleagues' (2009) second and third theories both examine how individuals treat their original pretest guesses. The second theory proposes that individuals suppress and hyper-correct their original pretest guesses when they are given the correct answers to the pretest questions. Kornell et al. argue that people are metacognitively aware that their pretest guesses are likely incorrect and so do not exert

any effort trying to remember them. Instead, individuals actively suppress these guesses from their memories so that they do not interfere with their ability to learn the correct answers during the later study phase. Thus, when a subject guesses the target word, ocean, during the pretest, she will deliberately and actively suppress this guess to enhance her ability to remember the studied target word, beach. This error suppression theory would suggest that people's pretest guesses are inaccessible at final test, thereby limiting potential errors and increasing the likelihood that they will be able to recall the correct answers. The researchers' third theory predicts the opposite effect of pretest guesses, suggesting that incorrect guesses at pretest are not suppressed, but are carefully encoded to encourage their retrievability at final test. Instead of interfering with subjects' ability to correctly recall the studied target at final test, an incorrect guess acts as an additional cue that mediates the ability to recall the correct target. For example, when a subject completes the word pair, tide—???, with his pretest guess, ocean, he will keep hold of this guess to help him remember the correct target, beach, at final test. Through mediation, this theory suggests that incorrect guesses at pretest enhance performance on the final test because participants have access to two cues to help them remember the correct target: the original question or cue itself, and their incorrect guess. Kornell et al. further advise that these three theories do not necessarily have to be independent of one another, as each theory may simply address different characteristics of the pretesting process.

Kornell et al.'s article (2009) inspired a new set of research questions aimed at establishing which (if any) of their pretesting theories best describe how pretests may exert their beneficial effects. It also provided a simplified pretesting paradigm, using

word pairs as study materials, to experimentally examine these theories. Their first theory, the semantic network activation hypothesis, was initially assessed by Grimaldi and Karpicke (2012). In that study, the researchers manipulated the relatedness of the to-be-studied word pairs, such that half of the pairs were weakly-associated with one another (i.e., tide—beach) while the other half of the pairs were unrelated (i.e., pillow—leaf). They argued that support for the semantic network theory would manifest itself through enhanced learning of weakly-associated word pairs relative to unrelated pairs following a pretest. According to this theory, when guessing the answers to pretest questions, people are believed to activate different memory traces that are semantically related to the pretest. Thus, it should be easier for individuals to recall the answers to the related word pairs than the unrelated ones. However, if the benefits of a pretest do not depend upon semantic networks, it would be assumed that participants should perform equally well on both types of word pairs. The results supported a semantic network theory: participants performed significantly better on the related pretested word pairs (73%) than the unrelated pretested word pairs (24%). More importantly, a pretesting effect was not found for unrelated pretested word (24%) pairs relative to a study-only condition (24%). Thus, a pretesting effect was only present for related word pairs.

In a similar study comparing subjects who either studied weakly-related or unrelated word pairs, Knight, Ball, Brewer, DeWitt, and Marsh (2012, Experiment 1) found similar results: a pretesting effect was only evident for related word pairs. Participants did not benefit from a pretest on unrelated word pairs. Instead, the researchers found a learning decrement for unrelated pretested word pairs relative to unrelated study-only word pairs. Additionally, when Knight et al. (2012) inquired about

the strategies that participants used to help them recall the correct targets at posttest, participants in the related condition most frequently reported relying on semantic features of the pairs, whereas participants in the unrelated condition claimed to use more phonological and surface features of the words. Across these two independent studies, the findings suggest that the pretesting effect is enhanced by greater semantic relatedness of the study materials.

As mentioned, Kornell et al.'s (2009) other two theories address the role that people's original pretest guesses may play in later learning acquisition. Whereas the error suppression theory suggests that people suppress their original pretest guesses, the mediation theory predicts that these guesses are encoded and recallable. Since the pretesting effect shows enhanced retrieval for pretested items relative to study-only items, these theories can be pitted against one another by asking participants to recall both their pretest guesses and the correct, studied answer at posttest. If enhanced learning for pretested versus study-only items is found and participants *can* recall their original guesses, this would support the mediation theory. However, if the pretesting effect is supported but participants are unable to recall their original guesses, this would support the error suppression theory. Knight et al. (2012, Experiment 3) conducted this study using word pairs. At pretest, participants were provided with a series of cue words and told to guess each corresponding target word before studying the cue-target pair. At posttest, they were instructed to recall both their original guesses and the studied targets. Support for a pretesting effect with evidence in favor of the mediation theory was found. Participants not only had access to their original pretest guesses during the posttest, but they were actually able to recall more of those guesses than the studied target words.

A similar study by Yan, Yu, Garcia, and Bjork (2014) corroborated Knight et al.'s research (2012) in favor of the mediation theory and expanded upon it. Yan et al. found that subjects not only had access to their original pretest guesses at posttest, but that being able to recall their original guesses facilitated their ability to correctly recall the studied targets, such that an individual was more likely to be able to recall the studied target if she was able to successfully recall her pretest guess. For pairs where she could not recall her original guess, her ability to remember the correct target was reduced. This study not only provides evidence that people have access to their original pretest guesses at the time of a final test, but goes on to suggest that access to these guesses enhances the ability to recall the correct information. Both of these studies thus reject the error suppression theory as a mechanism for how pretests exert their beneficial effects while providing converging evidence in favor of the mediation theory. Thus, of Kornell et al.'s (2009) original three theories explaining how pretests may enhance learning, there is empirical consensus in favor of both the semantic network activation and mediation theories. The pretest questions themselves activate an individual's semantic network for information related to those questions, leading to deeper processing of that information, and the specific answers they provide encourage learning by acting as an additional cue that can be accessed at final test to aid in the recall of the correct studied answer.

Pretesting effects as a function of question-type. The direction of the pretesting literature following Richland et al.'s work (2009) was useful in attempting to explore the mechanisms underlying the pretesting effect; however, the reliance on word pairs as study materials steered the research away from its original interest in real world applicability. Compared to prose passages, which are rife with syntactic and semantic

complexity, word pairs and the process of learning them may be too simplistic to substitute for, and generalize to, the types of materials that must be learned in a classroom setting. For example, the original testing effect research was carried out using prose passages as study materials (Roediger & Karpicke, 2006) with much of the research since also employing text and lecture-like study materials. In a commentary on that literature, Rawson (2015) indicated the universal benefits of tests relative to study alone to enhance learning regardless of the format of the study materials. However, she also reported that effect sizes were smaller in studies that used word lists as study materials compared to those using word pairs and prose passages. Although this finding should encourage greater use of word pairs or prose passage study materials in learning studies, prose passages seem to provide the most real-world applicability to the classroom.

Also relevant to concerns about real world application is the key finding from Richland et al.'s paper (2009) that pretests only enhance learning for material that was previously-seen and asked at pretest (intentional learning). There was no benefit at posttest for new information that was not asked about at pretest (incidental learning). This is a problem because it suggests that people would have to be pretested on all possible material for there to be an appreciable learning benefit on a final test, which is not ideal for a classroom setting. Rather, it would be preferable to provide students with a sampling of questions at pretest and find benefits for all posttest questions (old and new). It is possible though that Richland et al. did not find an incidental learning benefit because their test questions were closed-ended (i.e., fill-in-the- blank or one-word-answer) and could be answered in one or two words (i.e., "What color is tomato juice to Mr. I?;" Answer: Black; Richland et al., p. 256). While answering pretest questions has

been shown to promote deeper processing relative to study-alone, Richland et al.'s closed-ended questions may not have been deep enough to improve both intentional and incidental learning. Thus, it remains to be determined whether the lack of incidental learning following a pretest is a function of the type of questions that are asked or if a general characteristic of pretests is that they only enhance intentional learning.

As discussed above, the beneficial effects of pretests seem to rely upon mechanisms described by both the semantic network activation and mediation theories (Kornell et al., 2009). Thus, it is possible that a pretest will only enhance incidental learning processes if the elements described by those two theories are maximized by the pretest questions. For instance, a pretest that effectively and broadly primes one's semantic network to activate more pathways may provide deeper processing and benefits for both intentional and incidental learning compared to a pretest that activates fewer pathways. Given Richland et al.'s (2009) closed-ended questions could be answered in just a word or two, it is possible that participants' semantic networks were not activated *enough* to produce pretesting benefits that extended to incidental learning. A similar possibility exists with respect to mediation theory. It may be that more guesses at pretest, or simply more elaborative guesses, would provide individuals with a greater number of cues that they can use at posttest to retrieve or access the correct information. Such a situation may not occur with closed-ended questions that elicit answers comprising only a word or two. In contrast, use of open-ended questions (i.e., short-answer or essay-style) at pretest may be more effective for learning, as they can: a) be answered in many ways and still be correct, and b) can involve more than a single piece of correct information. Thus,

it is possible that open-ended pretest questions may enhance both intentional and incidental learning.

Only a few known studies have made use of open-ended pretest questions. Bull and Dizney (1973) presented participants with pretest questions that prompted substantial engagement with the study materials, particularly asking questions that required elaborative thought and more than one sentence to answer (e.g., "If teachers are generally viewed as middle class, why was it the Balinese of high caste who sent their daughters to be educated?"; Bull & Dizney, 1973, p. 46). Though the pretest questions *were* open-ended, the posttest only consisted of closed-ended, multiple-choice questions. Unfortunately, like the studies already described, the results only showed a pretesting benefit for intentional learning; there was no benefit of the pretest on incidental learning.

It is disappointing that open-ended pretest questions proved ineffective for incidental learning in Bull and Dizney's experiment (1973), but one reason could be the lack of match in question-type from pretest to posttest. Bull and Dizney asked open-ended-style pretest questions and closed-ended posttest questions; however, it is possible that the benefits of open-ended pretest questions depend upon transfer-appropriate learning processes that are only manifest when the same question format is used at both pretest and posttest. St. Hilaire et al. (2016) examined the effect of question-type match across pre- and post-tests by asking either closed- or open-ended pretest questions prior to study of a prose passage followed by closed- or open-ended posttest questions. Although they replicated the existing pretest literature, finding intentional learning benefits of a closed-ended pretest on a closed-ended posttest, there were neither intentional nor incidental learning benefits of asking open-ended pretest questions on an

open-ended posttest. These results were especially surprising given the effects of the open-ended pretest on intentional learning did not match those of the closed-ended pretests, although there was a trend in the right direction. It is possible that pretest benefits only occur for closed-ended questions that assess intentional learning; however, there were a few limitations in the study that could explain the non-significant open-ended pretest results. Primarily, St. Hilaire et al. (2016) noted that their study materials may have been too simple to ask effective open-ended test questions. The prose passage was only 275 words, and because it was so short, almost every sentence in the passage contained testable material. Thus, the study needs to be replicated with more complex text and question materials to determine whether the lack of open-ended pretest benefits were due to ineffective study materials or if open-ended test questions simply do not produce enhanced learning following pretesting.

Structure Building

It seems evident that the benefits of taking a pretest depend, in part, on the ability to engage one's semantic network when working with to-be-learned material (Grimaldi & Karpicke, 2012; Knight et al., 2012; Kornell et al., 2009). However, it is possible that different people have varying degrees of ability in being able to activate or make use of semantic relatedness, which may impact the magnitude of the pretesting effect. Individual differences in cognitive ability associated with semantic networks have been explored in a number of areas. Much of the recent research has honed in on a concept known as "structure building," a construct that reflects a person's ability to "build a cohesive, mental representation or 'structure'" of complex text material (Gernsbacher, Varner, & Faust, 1990, p. 431). The idea behind structure building is that when individuals are

learning or retrieving information, they use semantic, structural frameworks as the foundation for that information. If an individual is learning a piece of information that is *related to something they already know*, they will activate an existing framework for that information and map the new, incoming information to that framework as it relates. For example, when a student learns that the oceans' tides are closely related to the phases of the moon, she could combine both the ocean and moon constructs under one semantic structure, "oceans." However, *when learning new or unrelated information*, individuals can create a new sub-structure under an existing framework, or may even choose to create a new structure altogether (Gernsbacher et al., 1990). For example, when she later learns that whales are mammals, it would be possible that she could categorize whales under her already-existing "oceans" framework, but it may be more prudent for her to create a separate "animals" or "mammals" framework, since most mammals do not live in the ocean. Thus, successful structure building depends upon a person being able to: a) connect related concepts to one another, and b) identify when to not combine concepts such as when they are unrelated.

Gernsbacher and colleagues (1990) believe that a person's structure building ability is grounded in how effectively they are able to create cohesive structures when learning new material. It is believed that high-ability structure builders are able to generate complete structural representations of learned information by "building" all of the information that is pertinent to one structure at a time, and *inhibiting* information that is irrelevant to that structure. By contrast, low-ability structure builders have greater difficulty building coherent mental structures, and instead engage in "shifting" behavior. When learning new, related information, low-ability structure builders will

simultaneously shift across and build upon many structures at the same time so that each structure ends up having fragmented and incomplete pieces of information. For example, a low-ability structure builder may have difficulty connecting the moon with the oceans' tides, since the two concepts are spatially and thematically unrelated to one another, instead opting to create a two-structure model, one for "oceans" and a second for the "moon." Unless both structures are activated at the time of retrieval, an individual will struggle with being able to recall all of the learned information. Tying structure building back to Kornell et al.'s (2009) theory that learning is enhanced for information that is semantically related and activated suggests that high-ability structure builders may show enhanced memory and learning ability relative to low-structure builders. If all of the to-be-learned information can be retrieved from one semantic structure, rather than obtained from multiple structures, not only will memory retrieval be more efficient but retrieval should also be less susceptible to failures.

Structure building not only reflects how well an individual is able to integrate conceptually-similar information together in general, but also involves how well one is able to connect concepts together *across time*. Oftentimes a teacher's lesson plan may take more than one lecture to present. A low-ability structure builder would see each lecture as independent from the others, and create a different cognitive structure for each day of class. However, a high-ability structure builder would be able to draw parallels across multiple lectures, acknowledging that each successive lecture is an extension of the material built upon previously. The high-ability structure builder would thus create one, cohesive, conceptually-interrelated structure containing all of the relevant course material from multiple lectures. Not surprisingly then, structure building correlates well

with the verbal section of the SAT, high school GPA, and course grades in college (Arnold, Daniel, Jensen, McDaniel, & Marsh, 2016), reinforcing the idea that structure building is a useful individual difference variable to examine in memory and learning research.

Structure building as an individual difference variable. In addition to correlations between academic performance and structure building ability (Arnold et al., 2016), comparisons between low- and high-ability structure builders appear to show some interesting differences in learning style. For example, Callender and McDaniel (2007) compared low- versus high-ability structure builders' memories for an introductory psychology textbook chapter. First, the researchers found that, when simply asked to read and study the book chapter, high-ability structure builders did significantly better answering closed- and open-ended posttest questions than low-ability structure builders. However, Callender and McDaniel also included an experimental condition in which subjects were asked to answer a series of embedded, open-ended test questions every few paragraphs while reading over the book chapter, acting as a testing effect design with questions presented following just-read material. The results showed that the low-ability structure builders' memories were elevated to the same level as the study-only, high-ability structure builders, although this effect was qualified by the type of embedded test question. When low-ability structure builders were asked fact-based, verbatim-style questions that could be answered directly from the book chapter, their posttest performance was enhanced, but when they were asked to answer inference-style, conceptual questions that did not have a clear answer written in the text, there were no benefits. By contrast, high-ability structure builders showed no effect of answering

verbatim- nor conceptual-style open-ended embedded test questions. Callender and McDaniel (2007) argue that answering verbatim-style, embedded questions provides low-ability structure builders with concrete anchoring points by which to build a structural framework. High-ability structure builders though, do not benefit from answering embedded test questions because they are already able to create coherent, mental structures for novel material on their own.

In a related study, Bui and McDaniel (2015) compared how low- and high-ability structure builders engage with learning aids while listening to an audio lecture about car brakes. During the lecture, participants were provided with either a text outline or illustrative diagram about the to-be-learned material to see whether an additional study aid would enhance their ability to learn the material. Bui and McDaniel found similar results as Callender and McDaniel (2007). Without a learning aid, high-ability structure builders performed significantly better than low-ability structure builders on both closed- and open-ended posttest questions. Although participants generally benefited more from the illustrative diagram than the text outline, using a learning aid did not significantly affect high-ability structure builders' posttest performance. However, when low-ability structure builders had access to any learning aid during study, their posttest scores were raised to the same level as those of the high-ability structure builders.

Structure building and the pretesting effect. Although structure building has not been examined as an individual difference variable in pretesting effects, research on a relatively-similar construct, reading ability, has been explored. Memory (1983) examined how participants' reading ability (low- vs. high-ability) may influence how much individuals benefit from answering closed-ended pretest questions. The results showed

that answering pretest questions only provided a learning benefit for low-ability readers relative to study-only participants; high-ability readers given a pretest did not show any enhancement on a final test relative to a study-only condition. Memory (1983) argued that answering pretest questions enhances learning by providing individuals with a pre-study framework to emphasize the most important points from the study materials and provides an organizational structure by which to direct attention. He believed that high-ability readers did not benefit from pretesting because they were already using effective organizational skills when they read. Similar results were found in a replication study by Dowaliby (1990) who also compared pretesting effects between low- and high-ability readers using closed-ended test questions.

This research indicates that individual differences can predict the degree of learning benefits provided by answering pretest questions, and more specifically, suggests that individual differences in structure building may be particularly relevant. However, no known research has gone beyond the work of Memory (1983) and Dowaliby (1990) to examine whether a relationship exists between pretesting benefits and structure building ability as it is currently conceptualized and assessed. It can be extrapolated though from the aforementioned work that low- and high-ability structure builders should differentially benefit from answering pretest questions, but such differences have yet to be explored. Similarly, no known research has examined individual differences in pretesting effects across different pretest question-types, namely open- vs. closed-ended questions. The pretesting literature has only examined individual differences as they relate to answering closed-ended pretest questions (Dowaliby, 1990; Memory, 1983).

The Present Study

The present study was undertaken to examine the efficacy of answering open-ended pretest questions when paired with open-ended posttest questions on learning. More specifically, it was designed to determine: a) whether asking open-ended questions at both pretest and posttest enhances intentional learning in the same manner that closed-ended pretest questions do on a closed-ended posttest, and b) whether asking open-ended pretest and posttest questions enhances incidental learning (i.e., learning of information not queried at pretest). This study builds upon previous work by St. Hilaire et al. (2016) by using more complex and demanding study materials and test questions.

A secondary goal of the present study was to examine how individual differences in structure building ability may relate to the pretesting effect. More specifically, structure building was measured to determine whether the magnitude of the pretesting effect may be impacted by differences in the capacity to create coherent mental structures of complex text. Further, the interaction between structure building and pretest question-type was explored to see if the pattern of individual differences identified in earlier reading ability work (Dowaliby, 1990; Memory, 1983) would be present for both closed- and open-ended pretest questions.

Participants were assigned to one of four groups defined by pretest question-type (closed-ended vs. open-ended vs. no-pretest) and posttest question-type (closed-ended vs. open-ended; see Figure 1 for study design). Thus, participants either took a pretest consisting of closed- or open-ended questions and then studied a prose passage about "Brakes" (Mayer & Gallini, 1990; see Appendix A) or just studied the prose passage. The posttest followed, and for subjects assigned to take a pretest, question-type was matched

across pretest and posttest. In addition, all test questions were designed such that the answers could be obtained directly from the prose passage itself (i.e., verbatim questions). Following the posttest, participants completed the Multi-Media Comprehension Battery (MMCB; Gernsbacher & Varner, 1988) to measure structure building ability.

Based on the literature discussed above, it was expected that the results would replicate Richland et al.'s (2009) original pretest finding that taking a closed-ended pretest would enhance intentional learning on a closed-ended posttest, but show no benefit for incidental learning. By contrast, it was hypothesized that an open-ended pretest followed by an open-ended posttest would enhance both intentional and incidental learning.

Further, it was believed that individual differences in structure building ability would differentially affect gains from pretesting. More specifically, although high-ability structure builders should outperform low-ability structure builders overall, only low-ability structure builders were expected to benefit from answering closed-ended pretest questions (Dowaliby, 1990; Memory, 1983). Closed-ended pretest questions were assumed to be of little use for high-ability structure builders given they already employ effective structural frameworks when learning information. In contrast, predictions for the effects of open-ended pretest questions were more uncertain as no known research has examined individual differences as they relate to this type of pretest question. However, one possibility is that open-ended pretest questions will only enhance learning for low-ability structure builders as was hypothesized for closed-ended pretest questions. Alternatively, open-ended pretest questions may enhance learning solely for high-ability

structure builders. It may be the case that open-ended pretest questions do not offer enough scaffolding to benefit low-ability structure builders but do provide a useful starting point to assist or boost what high-ability structure builders already do.

METHOD

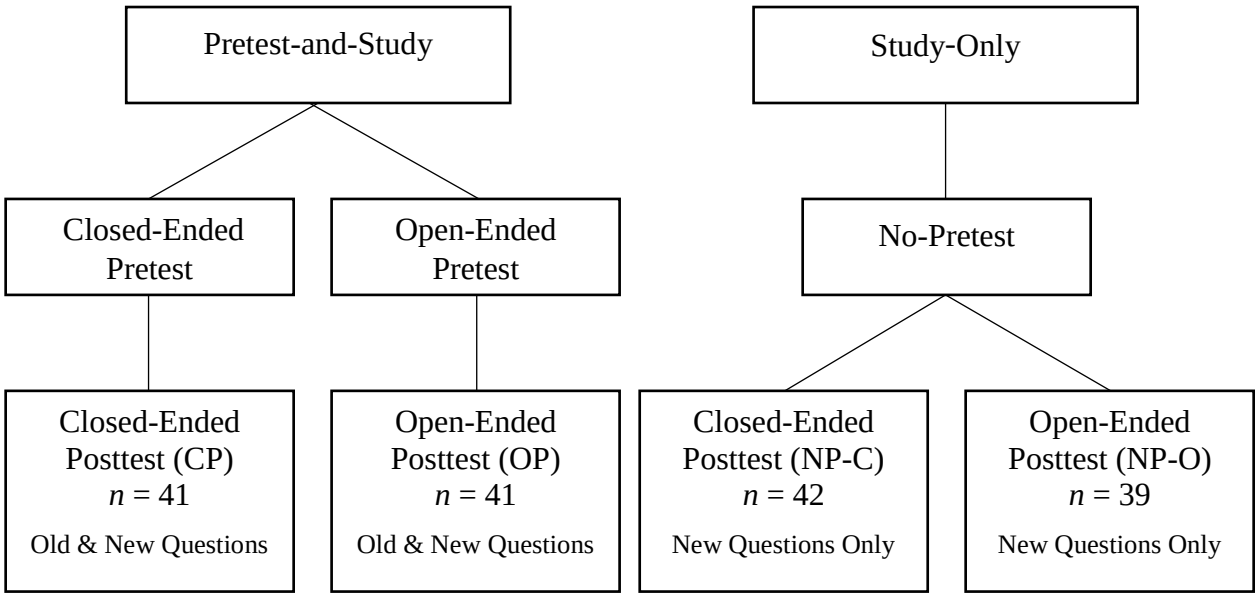
Participants

One-hundred and sixty-three introductory psychology students were recruited from the Wake Forest University Subject Pool to participate in partial fulfillment of their course requirement. The sample was comprised of 66 female and 97 male participants between the ages of 18 and 22 years (M = 19.16, SD = 1.06). The study was approved by the Wake Forest University Institutional Review Board, and participants signed an informed consent form before any data were collected. Participants were randomly assigned to one of four groups with sample size ranging from 39 to 42 subjects per group (see Figure 1), a sample size that was based on previous work suggesting that thirty participants per group is sufficient to show significant effects (Richland et al., 2009).

Design

The four experimental groups were defined by the pairings of the pretest and posttest conditions (Figure 1). During the pre-study phase, participants were assigned to take either a closed-ended or open-ended pretest, or were assigned to a no-pretest study group. At posttest, all participants took a closed-ended or open-ended posttest. Participants assigned to a pretest condition took a posttest using the same question format as their pretest. Thus, the four experimental groups consisted of: a) a closed-ended pretest/closed-ended posttest (CP) group, b) an open-ended pretest/open-ended posttest (OP) group, c) a no-pretest/closed-ended posttest (NP-C) group, and d) a no-pretest/open-ended posttest (NP-O) group.

Figure 1
Study Design Depiction Showing the Four Pretest and Posttest Conditions with their Samples Sizes



Materials

A 675-word prose passage about "Brakes" (Mayer & Gallini, 1990; Appendix A) was used for the study materials. This text passage discusses three different types of vehicular braking systems, and describes the mechanical structure and function of each one. It was believed this "Brakes" text passage would be long and complex enough to allow for effective closed- and open-ended test questions.

Pretest and posttest questions. Verbatim test questions were constructed from the "Brakes" text passage using the same style and format as those described by Richland et al. (2009). A total of 10 closed-ended test questions such as "What are cylinders and brake lines filled with?" (Appendix B) and four open-ended test questions such as "What

is the primary difference between mechanical brakes and hydraulic brakes?" (Appendix C) were used. The closed- and open-ended test questions were developed so that each question format assessed the same concepts and material from the passage. For example, concepts tested across two or three closed-ended questions were also assessed by one broader, open-ended question. The pretests included either five closed-ended or two open-ended questions (i.e., Richland et al., 2009; St. Hilaire et al., 2016) and two versions of each type of pretest (closed- vs. open-ended questions) were created so that every question was asked at pretest. The administration of the test versions was counterbalanced across participants.

The posttests included all 10 closed-ended or all four open-ended questions. By design, participants assigned to a pretest condition would have read and attempted half of the posttest questions during the pretest with the other half of the questions being new at the time of the posttest (see Figure 1). For participants in the no-pretest conditions, all of the posttest questions were new.

Questionnaires and assessments. Questionnaire packets were constructed to include a demographic questionnaire (see Appendix D), the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982), and the Self-Control Questionnaire (SCQ; Tangney, Baumeister, & Boone, 2004). The demographic questionnaire asked participants to report their gender identity and age (in years). The CFQ is a 25-item measure (α = .89) asking people about their memory failures and everyday errors. One example item from this questionnaire asks, "Do you read something and find you haven't been thinking about it and must read it again?" with participants choosing the option that best describes them: "never;" "very rarely;" "occasionally;"

"quite often;" and "very often." The SCQ is a 10-item measure (α = .89) that examines people's ability to regulate their impulses and exert self-discipline. For instance, one item from the SCQ includes, "I have a hard time breaking bad habits," and asks participants to rate how much each phrase characterizes them on a five-point scale ranging from: "not like me at all" to "very like me." The CFQ and SCQ were used as filler tasks to prevent participants from thinking about the prose passage during the retention interval between study and the administration of the posttest. Consequently, the data were not analyzed for this project.

Finally, the MMCB was included to measure individuals' structure building ability (Gernsbacher & Varner, 1988; see Appendix E). The MMCB consists of three modalities: written, auditory, and pictorial; however, because the three modalities correlate well with one another (Gernsbacher, Varner, & Faust, 1990), only the written modality was used as has been done elsewhere (Arnold, Daniel, Jensen, McDaniel, & Marsh, 2016; Bui & McDaniel, 2015; Callender & McDaniel, 2007; Martin, Nguyen, & McDaniel, 2016). This component of the MMCB consists of four short stories between 538 to 957 words with each one accompanied by a set of 12 short answer questions (α = .99; Gernsbacher, Varner, & Faust, 1990; see Appendix E). Using a strict grading rubric described by Gernsbacher and Varner (1988), each short-answer question was scored out of a maximum of three points. Thus, across the four stories and 48 test questions, total scores could range from 0 to 144 points with higher scores indicating greater structure building ability.

Procedure

Participants carried out the study in small groups ranging from two to 12 individuals per testing session. All participants in each testing session were assigned to the same experimental condition (e.g., OP) to maintain the timing of the pretest and study phase for all participants within a session. The order of administration for each experimental condition was randomized across testing sessions, and the study materials were administered using paper and pencil format.

Individuals assigned to a pretesting condition began the study by spending the first two minutes of the experiment taking the pretest on the "Brakes" passage. Participants were instructed to attempt a response for each pretest question regardless of whether they knew the answer. Thus, guessing was encouraged; however, feedback and correct answers to the pretest questions were not provided. After completing the pretest phase of the study, the pretest documents were collected, and participants were then given eight minutes to study the "Brakes" prose passage for the memory test that would follow. Subjects were encouraged to write on and mark up the prose passage document if they thought that would help them as they studied. Participants assigned to the no-pretest, study-only condition engaged with the experimental materials for the same amount of time as the pretest groups, but did so by studying the "Brakes" passage for the entire 10 minute period. The same study instructions were provided for all conditions; participants were told to read and study the prose passage and that their memory for it would be tested afterwards.

After completing the study phase of the experiment, the sheets with the prose passage on them were collected, and all participants were given a five-minute retention

interval during which they were asked to provide answers to the demographic questionnaire, the CFQ, and the SCQ. Participants were then given the closed-ended or open-ended posttest depending on the experimental condition to which they were assigned. The posttest was untimed, but took approximately five minutes to complete. The tests were collected when all participants finished.

After the posttest, the MMCB was administered using the procedures described by Gernsbacher, Varner, and Faust (1990). Participants were instructed to read each of the four stories only once and, immediately after reading each story, to complete its corresponding test. The timing for reading each story and completing each test was self-paced, but most participants completed the MMCB in less than 30 minutes. Participants were free to leave when they finished the fourth story and test pair, at which time they were thanked for their participation and awarded research credit.

RESULTS

Participants' pretest and posttest answers were scored using a stringent coding scheme to maintain consistency in grading (see Appendices B and C). Each pretest and posttest was scored out of 5 and 10 points, respectively, and accuracy was recorded as the proportion of questions answered correctly. In addition, posttest questions were coded as either "old" or "new" with "old" referring to questions that were asked at both pretest and posttest and "new" representing those asked at posttest for the first time. Therefore, participants not assigned to a pretest condition (NP-C, NP-O) have scores for only "new" questions while those who took part in a pretest condition (CP, OP) have both "old" and "new" scores (Figure 1). *Intentional learning* was thus assessed by comparing performance on old items for the CP and OP groups to the NP-C and NP-O groups' performance on new items whereas *incidental learning* was evaluated by comparing performance on new items between the pretested and study-only groups. As such, posttest scores for the participants who did not take a pretest (i.e., new item performance) can be viewed as a form of baseline performance against which to compare the effects of pretesting.

Pretest Performance

The first set of analyses examined how much participants tried, and how well they performed, on the closed- and open-ended pretest questions. An independent samples t-test showed that there was no significant difference in the proportion of pretest questions that participants attempted to answer with CP participants attempting 82% and OP participants attempting 79% of the pretest questions, $t(80) = .50$, $p = .62$, $d = .10$. However, a second independent samples t-test indicated that CP participants performed

significantly better on the pretest questions (9%) compared to the OP participants (3%), $t(80) = 2.42$, $p = .018$, $d = .54$. Although participants equally attempted to answer the closed- and open-ended pretest questions, they showed greater performance on the closed-ended relative to the open-ended pretest questions. Nonetheless, most pretest responses were incorrect and were errors of commission rather than omission.

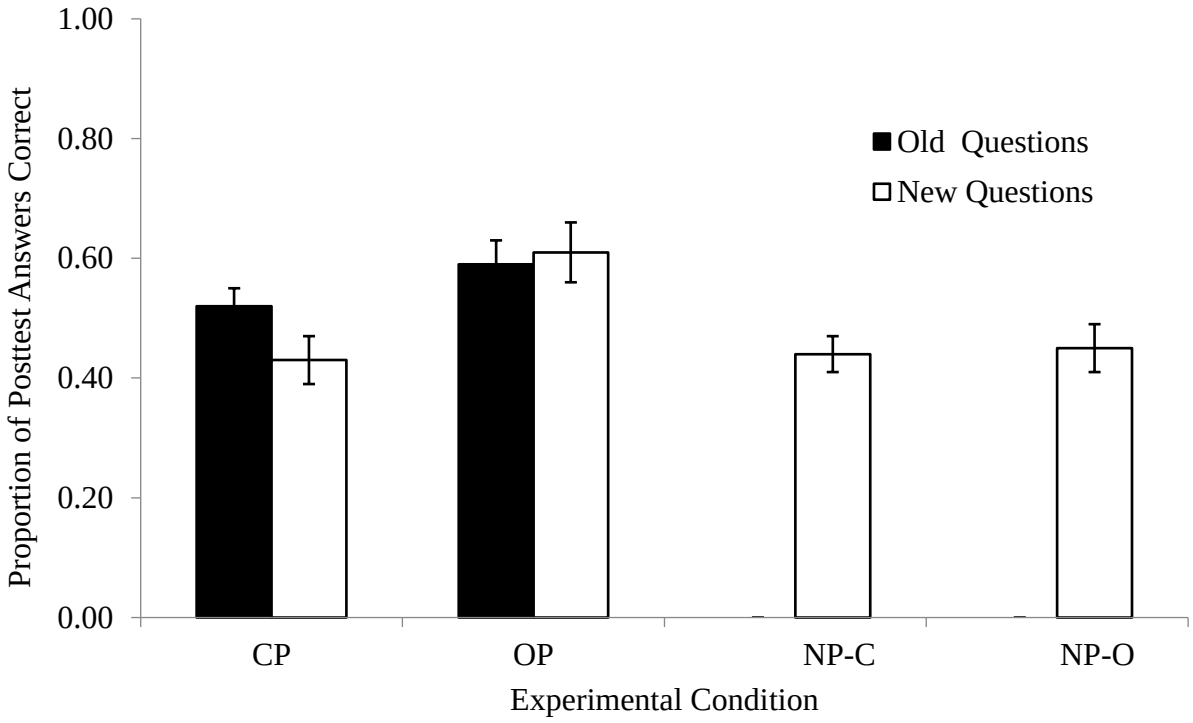
Effects of Answering Pretest Questions on Posttest Performance

Intentional learning. To examine how well the CP and OP participants performed on *old questions* relative to how well the NP-C and NP-O participants performed on *new questions* at posttest, a 2 (pretest vs. no-pretest) x 2 (question-type: closed- vs. open-ended) between-subjects ANOVA was conducted. The main effect of pretest condition was significant, showing an intentional learning benefit for both pretest groups (CP and OP) on old questions ($M = .55$, $SE = .03$) when compared against the study-only groups' performance (NP-C and NP-O) on the new questions ($M = .45$, $SE = .03$), $F(1, 159) = 9.25$, $p < .001$, $\eta^2 = .06$ (see Figure 2). However, the main effect of question-type (closed- vs. open-ended) and the two-way interaction between presence/absence of a pretest and question-type were not significant, Fs ≤ 1.41, ps $\geq .24$, η^2s $\leq .009$, suggesting that pretesting benefits were present for both the CP and OP groups. Nonetheless, two planned independent t-tests (one-tailed) were conducted to ascertain if the observed intentional pretesting benefits were significant for the two pretesting conditions. There proved to be a significant difference between performance by the CP group on old posttest questions ($M = .52$, $SE = .04$) relative to the NP-C group's performance on new posttest questions ($M = .44$, $SE = .03$), $t(81) = 1.76$, $p = .041$, $d = .41$ (see Figure 2). Similarly, the OP group did significantly better on old

questions (*M* = .59, *SE* = .04) than the NP-O group did on new questions (*M* = .45, *SE* = .04), *t*(78) = 2.47, *p* = .008, *d* = .57. Together, these results show benefits of answering closed- or open-ended pretest questions on intentional learning.

Incidental learning. To determine whether performance on the *new posttest questions* differed as a function of pretesting, a second 2 (pretest vs. no-pretest) x 2 (question-type: closed- vs. open-ended) between-subjects ANOVA was conducted. The main effect of pretest condition was marginally significant (see Figure 2), showing a slight incidental learning benefit for the pretested (CP and OP) participants on new posttest questions (*M* = .52, *SE* = .03) relative to the study-only (NP-C and NP-O)

Figure 2
Effects of Pretest Condition on Posttest Performance for Old and New Questions



participants (M = .45, SE = .03), $F(1, 159) = 3.62$, p = .059, η^2 = .02. The main effect of question-type was significant indicating that incidental learning benefits at posttest were greater for the open-ended questions (OP and NP-O conditions collapsed; M = .53, SE = .03) than for the closed-ended questions (CP and NP-C conditions collapsed; M = .44, SE = .03), $F(1, 159) = 6.34$, p = .013, η^2 = .04. In addition, the two-way interaction between the presence/absence of a pretest and question-type was significant, $F(1, 159) = 4.83$, p = .029, η^2 = .03. Two planned independent t-tests (one-tailed) were conducted, providing clarification of the interaction effect. There was a significant difference on the new posttest questions for the OP participants (M = .61, SE = .04) relative to the NP-O participants (M = .45, SE = .04), $t(78) = 2.60$, p = .006, d = .60 (Figure 2). However, there was no such difference between the CP (M = .43, SE = .04) and the NP-C participants (M = .44, SE = .04), $t(81) = .41$, p = .41, d = .05. Together, these results suggest that the marginal pretesting and significant question-type main effects were qualified by the interaction. More specifically, the incidental learning benefits seen at posttest were driven by the OP participants' performance.

Effects of Structure Building as an Individual Difference Variable

The next set of analyses were conducted to determine if structure building ability may function as an individual difference variable that influences pretesting benefits. As such, participants in each of the four experimental conditions were sorted into low- and high-ability structure builders based on their MMCB scores. Following a procedure used by McDaniel, Hines, and Guynn (2002), participants with structure building scores in the 32nd percentile and below were coded as low-ability structure builders, and those with scores in the 69th percentile and above were coded as high-ability structure builders. Data

for only these individuals were analyzed and sample sizes ranged from 9 to 18 participants per group (see Table 1). Note, for the following analyses, only results relevant to structure building are presented as the effects described above were not expected to change.

Structure building and intentional learning. To examine whether structure building ability influenced intentional learning benefits on *old posttest questions* for the CP and OP participants relative to the *new posttest questions* for the NP-C and NP-O participants, a 2 (pretest vs. no-pretest) x 2 (question-type: closed- vs. open-ended) x 2 (structure building ability: low- vs. high-ability) between-subjects ANOVA was conducted. The main effect of structure building was significant, showing that high-ability structure builders (M = .61, SE = .03) did better on the posttest questions than low-ability structure builders (M = .38, SE = .03), $F(1, 97) = 35.51$, $p < .001$, $\eta^2 = .27$. The two-way interactions between structure building and pretest condition (pretest vs. no-pretest), and structure building and question-type (closed- vs. open-ended) were not significant, Fs ≤ 2.14, ps $\geq .15$, η^2s $\leq .02$. In contrast, the three-way interaction between pretest condition, question-type, and structure building ability was marginally significant, $F(1, 97) = 2.99$, $p = .087$, $\eta^2 = .03$. Whereas CP low-ability structure builders showed a *greater* intentional learning benefit for old posttest questions relative to low-ability NP-C participants' performance on new questions, the CP high-ability structure builders showed *no* intentional learning benefit on old posttest questions relative to high-ability NP-C participants. In contrast, low-ability OP structure builders showed a slight

Table 1
Performance for Low- and High-Ability Structure Builders in Each Experimental Group on Old and New Posttest Questions

		CP	OP	NP-C	NP-O
Low	Old	.45 (.05)	.31 (.06)	--	--
	New	.28 (.06)	.44 (.07)	.37 (.05)	.40 (.07)
		n = 13	*n* =10	*n* = 18	*n* = 11
High	Old	.59 (.05)	.69 (.05)	--	--
	New	.59 (.06)	.65 (.06)	.58 (.07)	.58 (.08)
		n = 15	*n* = 17	*n* = 12	*n* = 9

intentional learning *decrement* on old posttest questions relative to low-ability NP-O. However, high-ability OP structure builders showed a *greater* intentional learning benefit on old posttest questions than the high-ability NP-O participants. Although not significant, and underpowered, these results provide a preliminary indication that low-ability structure builders may only experience intentional learning benefits from answering closed-ended pretest questions, whereas high-ability structure builders' learning is enhanced by open-ended pretest questions.

Structure building and incidental learning. To determine whether incidental learning benefits were impacted by structure building ability across the four experimental conditions (all new posttest questions), another 2 (pretest vs. no-pretest) x 2 (question-

type: closed- vs. open-ended) x 2 (structure building ability: low- vs. high-ability) between-subjects ANOVA was conducted. Only the main effect of structure building ability was significant, suggesting that high-ability structure builders (M = .60, SE = .03) scored higher on the new posttest questions than the low-ability structure builders (M = .37, SE = .03), $F(1, 97) = 23.71$, $p < .001$, $\eta^2 = .20$. Neither of the two-way nor the three-way interactions were significant, Fs ≤ 1.97, ps $\geq .29$, η^2s $\leq .01$, suggesting that structure building may not affect incidental learning benefits, although statistical power makes this conclusion tentative.

DISCUSSION

Pretesting Effect

The present study replicates earlier pretesting literature (e.g., Richland et al., 2009; St. Hilaire et al., 2016) in showing that guessing the answers to closed-ended pretest questions can enhance intentional learning for that same information on a closed-ended posttest. However, answering closed-ended pretest questions did not provide incidental learning benefits. That is, pretest-and-study participants (CP group) did not show any learning advantage relative to those in a study-only condition (NP-C group) when tested for information that was not queried during the pretest. This finding was not unexpected given the extant literature; it has been well-established that closed-ended pretest questions have no effect on incidental learning when using text materials (Richland et al., 2009; St. Hilaire et al., 2016; see also Frase, 1968; Little & Bjork, 2016; Pressley et al., 1990). The current findings also indicate that the "Brakes" prose passage (Mayer & Gallini, 1990) and the closed-ended test questions used here were effective materials for producing the type of pretesting effects that have been found elsewhere (Frase, 1968; Pressley et al., 1990; Richland et al., 2009; St. Hilaire et al., 2016).

Moreover, the present study advances previous pretesting research by showing there can be *intentional learning* benefits following a pretest comprised of open-ended questions when participants are given an open-ended posttest. Although intentional learning benefits have been found following open-ended pretest questions when assessed on a closed-ended posttest (Bull & Dizney, 1973), no prior work has explored the potential for intentional learning benefits using an open-ended pretest and a matched-format posttest. However, the most compelling result from the current study is that the

effects of pretesting with open-ended questions extended to *incidental learning*, enhancing performance on new, previously-unseen information at posttest. This is the first known study using prose passage study materials to find both intentional and incidental learning benefits following a pretest. Thus, it would seem to be the case that answering open-ended pretest questions prior to study can be an effective learning tool improving acquisition of new, untested knowledge as well as old, previously-seen information.

Benefits provided by answering pretest questions have been explained using Kornell and colleagues' (2009) semantic activation and mediation theories. As described earlier, semantic activation theory argues that answering pretest questions primes and activates one's semantic network for the to-be-tested information whereas mediation theory suggests that the pretest guesses themselves function as additional cues that facilitate a person's ability to retrieve the studied information. Further, the mechanisms described by these two theories could both be involved in producing pretesting effects. Consequently, the expectation for the current study was that while close-ended questions can encourage spreading activation of pretested information and provide subjects with additional retrieval cues, those effects would be maximized by answering open-ended pretest questions, resulting in more pervasive learning. More specifically, this was thought to occur because open-ended pretest questions can simultaneously activate many different concepts and be answered in multiple ways, unlike closed-ended test questions which often only have a single answer and thus activate just one semantic concept at a time. The results from the present study seem to support this view. The open-ended test questions showed a larger intentional learning effect size (OP vs. NP-O; d = .57) than the

closed-ended test questions (CP vs. NP-C; d = .41), suggesting that, while both types of pretest questions produced intentional learning benefits, those benefits were stronger following open-ended pretest questions. Further support comes from finding that open-ended pretest questions additionally led to incidental learning, which has been absent from pretesting studies that employ closed-ended test questions.

However, it should be noted that an earlier research attempt by St. Hilaire et al. (2016) failed to find significant intentional (M_{OP} = 72% vs. $M_{NP\text{-}O}$ = 66%) and incidental benefits using open-ended pretest questions (M_{OP} = 62% vs. $M_{NP\text{-}O}$ = 66%) despite seeing intentional learning with close-ended questions (M_{CP} = 79% vs. $M_{NP\text{-}C}$ = 65%). Although St. Hilaire et al.'s (2016) study was believed to be underpowered, it also seems to have differed from the current work in other ways. For instance, St. Hilaire et al.'s (2016) observed effect size for intentional learning using closed-ended pretest questions (d = .80) was substantially larger than seen here (d = .41), while the effect of open-ended questions was obviously smaller (d = .29) than the present study (d = .57). One possibility for this discrepancy could be the conceptually different-style study materials employed in the two experiments. Whereas the "Sun" prose passage (Rogers, 2001) used by St. Hilaire et al. (2016) was short and conceptually simple, the "Brakes" prose passage used in the present study was longer and more conceptually complex. There may have thus been a text passage by question-type interaction. It could be that simple and easy-to-comprehend text materials show greater benefits following closed- rather than open-ended test questions as was observed by St. Hilaire et al. (2016). By contrast, the more complex text materials used in the present work may produce greater learning benefits when combined with open-ended test questions. Future research should be conducted to

investigate this possibility by determining whether closed- and open-ended pretest questions are differentially effective as a function of using simple or complex text materials.

Although the present study is the first to successfully show incidental learning using prose passage study materials, research by Carpenter and Toftness (2016) found incidental learning through the use of *video* study materials. Employing the same pretesting paradigm as previous research (Kornell et al., 2009; Richland et al., 2009), participants were assigned to either a pretest-and-study or a study-only condition with study materials involving lecture-style videos rather than word pairs or prose passages. At posttest, pretest-and-study participants showed significant intentional and incidental learning benefits compared to the study-only participants. Carpenter and Toftness explained that incidental learning benefits may have arisen from a "spill over" effect of the video-style study materials. Since participants could not predict when the answers to the pretest questions would be presented, they were required to carefully listen to the entire video, which thus enhanced learning for both old and new material at posttest. Although Kornell et al.'s (2009) semantic activation and mediation theories have worked when explaining pretesting effects for written materials (i.e., word pairs, prose passages), it is unclear whether these theories can be applied to understand how video-style materials enhance incidental learning. Rather, it seems that pretesting followed by lecture or video study materials may enhance learning through attention-related processes that are unique to those materials. Given Carpenter and Toftness's (2016) experiment and the present study were both successful in finding incidental learning benefits, an interesting follow-up experiment could incorporate open-ended test questions with video-style study

materials to examine whether the previously-seen incidental learning benefits observed in the two studies may be additive.

Structure Building

This is one of the first studies examining structure building as an individual difference variable that may influence pretesting effects. Unsurprisingly, high-ability structure builders performed better on the posttest than low-ability structure builders, regardless of pretest condition, which is consistent with other literature showing that structure building ability can predict general test performance (Arnold et al., 2016; Bui & McDaniel, 2015; Callender & McDaniel, 2007). Finding large enough differences in structure building to yield differential posttest performance between high vs. low structure buildings (as assessed by the MMCB) was important for the current study due to concerns that the sampled population may have been too similar in ability. Given the participants were recruited from a homogenous population of high-achieving introductory psychology students at a small private university, it was reassuring to find that the MMCB was sensitive enough to detect differences in structure building to the extent needed to explore it as an individual differences variable.

Although there was a main effect of structure building ability, the interaction reflecting the relationship between *intentional learning* and structure building ability as a function of question-type only approached significance. As described above, the original prediction for closed-ended pretest questions was that low- but not high-ability structure builders would show learning benefits. By contrast, there were two possibilities for how structure building could impact the effect of open-ended test questions: 1) only the low-ability structure builders would benefit, as expected for closed-ended test questions; or 2)

learning would only be enhanced for high-ability structure builders. The trends in the data suggest that, indeed, only low-ability structure builders showed intentional learning benefits after answering closed-ended pretest questions. The high-ability structure builders did not display any intentional learning gains following closed-ended pretest questions. For open-ended pretest questions though, it appeared that intentional learning may have only been enhanced for high-ability structure builders. Unfortunately, as indicated, the overall three-way interaction effect was marginally significant, likely because the structure building element of the current study was underpowered (power was 40% using the observed effect size). It is possible that an interaction effect showing closed-ended pretest benefits for low-ability structure builders and open-ended pretest benefits for high-ability structure builders would reach statistical significance if more subjects were added to each low- and high-ability structure building group. A follow-up power analysis using the observed effect size showed that, for 80% confidence in finding the proposed interaction, 17 subjects would have to be included in the low- and high structure building groups for each of the pretest-and-study and study-only conditions.

As for incidental learning benefits, structure building ability was not found to significantly influence that pretesting effect. It may be the case that effects for both closed- and open-ended pretest questions are similar for the low- and high-ability structure builders. However, again, given the structure building analyses were underpowered (a follow-up power analysis indicated only a 7% chance of finding a significant three-way interaction using the observed effect size), the question is open.

It is disappointing that there was no significant interaction between structure building ability and posttest performance for intentional or incidental learning, but

structure building was included in the current study as an exploratory, secondary goal for the research design. Although it would have been preferable to assign low- and high-ability structure builders to each experimental condition prior to data collection, the timeline for carrying out the current work and subject pool availability made it impossible to do. However, given the effects of structure building seen here can be viewed as largely pilot data, the results do encourage follow-up. With more control over how low- and high-ability structure builders are assigned to groups, and with greater statistical power, more reliable interaction effects should be manifest.

Conclusions

The present study successfully replicated previous research showing intentional learning benefits for closed-ended pretest questions, but more importantly, extended the pretesting literature to show both intentional and incidental learning benefits for open-ended pretest questions. This research could be used to advise educational practice as it suggests that pretests may be an effective intervention to enhance learning acquisition. Pretest assessments would be relatively simple to implement in a course curriculum as pretest questions are not challenging to construct, and, similarly, only take a few minutes to administer. Thus, the current research implies that open-ended pretest questions could be employed as a successful teaching intervention to help improve incidental learning. However, the structure building results, if replicable, could have even stronger educational implications by suggesting that open-ended pretest assessments would be most beneficial for high-ability structure builders who already have strong organizational and reading comprehension capabilities. In contrast, answering closed-ended pretest questions may be more helpful for low-ability structure builders.

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APPENDIX A

Brakes Text Passage (Mayer & Gallini, 1990)

Brake is a device that slows or stops a moving object. Most brakes have a part called a brake pad or brake shoe that presses against a turning wheel—or a unit connected to the wheel—to produce friction. This friction converts the wheel's energy of motion to heat, slowing or stopping the wheel. Vehicles and industrial machines use a wide variety of brakes. This article describes brakes used chiefly in vehicles.

Vehicles are equipped with three major kinds of brakes: (1) mechanical brakes, (2) hydraulic brakes, and (3) air brakes.

Mechanical brakes have levers or cables that force one or two pads against the wheel. Most bicycles have two mechanical brakes called caliper brakes, one for each wheel. Each brake has two small rubber pads, one on each side of the wheel rim. The pads are mounted on a mechanical device that is connected to one end of a long cable. The other end of the cable is connected to a lever on the handlebar. When the rider squeezes this lever, force on the cable presses the pads against a wheel rim.

Automobiles are equipped with another kind of mechanical brake called an emergency brake or hand brake. This brake is also known as a parking brake because it helps prevent a parked car from rolling away. When the driver applies the emergency brake, a system of levers, rods and cables applies pressure to the pads or shoes of the rear wheels.

Hydraulic brakes use a special liquid called brake fluid to apply brake pressure to pads or shoes. Most automobiles have a hydraulic braking system. The main parts of this system are a chamber called a master cylinder, which is located near the brake pedal; at least one wheel cylinder at each wheel; and tubes called brake lines, which connect the master cylinder to the wheel cylinders. The cylinders and brake lines are filled with brake fluid.

Inside the master cylinder is a piston which can slide back and forth. In a simple hydraulic system, the brake pedal controls this piston by means of a rod or some other mechanical link. When the driver pushes on the pedal, the piston inside the master cylinder exerts pressure on the fluid and slides forward a short distance. The fluid transmits this pressure through the brake lines, forcing pistons in the wheel cylinders to move forward. As the wheel cylinders move forward, they apply brake pressure to pads or shoes.

The wheel cylinders are mounted in either disc brakes or drum brakes. Most cars have disc brakes on the front wheels and drum brakes on the rear wheels.

Disc brakes have a disc, which is usually made of cast iron, attached to the vehicle's axle. The wheel is attached to the disc. A U-shaped caliper assembly fits around a part of the disc but does not rotate with the disc. This assembly includes one or two wheel cylinders, each containing a piston and two brake pads—one on each side of the disc. The pads are flat pieces of metal lined with a heat-resistant material. When the brake is applied, the pads press inward against the disc.

Drum brakes have a drum, usually cast of iron, fastened to the axle. The wheel is attached to the drum. Inside the drum are two semicircular brake shoes that are lined with heat-resistant material. The shoes do not rotate with the drum. Between the shoes is a wheel cylinder. The cylinder has two pistons, which push in opposite directions—one against each shoe. When the brake is applied, the shoes press outward against the drum.

Air brakes use compressed air supplied by a machine called a compressor. Most buses, heavy trucks, and trains have air brakes. When the driver or engineer applies the brakes, a storage unit releases compressed air. The air pushes against a piston or diaphragm, which applies brake pressure to pads or shoes. Buses and trucks have disk and drum brakes like those in automobiles. In trains, however, shoes press against the outside of the wheel.

APPENDIX B

Closed-Ended Test Questions

1. Mechanical brakes have levers or _____ that force one or two pads against the wheel.
    - Cables (1)

2. _____ and brake lines filled with brake fluid.
    - Cylinders (1)

3. For hydraulic brakes, what kind of wheel cylinder is on the front wheel?
    - Disc brakes (1)

4. For drum brakes, when the brake is applied, the shoes press in what direction against the drum?
    - Outward (1)

5. A piston slides back and forth in the _____.
    - Master cylinder (1)

6. Air brakes use _____ to apply brake pressure to the pads or shoes.
    - Compressed air (1)

7. What type of machine relies on caliper brakes?
    - Bicycle (1)

8. Brake pads press against a turning wheel to produce friction that converts the wheel's energy of motion to _____.
    - Heat (1)

9. On which of a car's wheels does the emergency brake exert its force?
    - Rear wheels (1)

10. How many different kinds of brakes are vehicles equipped with?
    - Three (1)

APPENDIX C

Open-Ended Test Questions

1. What is the primary difference between mechanical brakes and hydraulic brakes? (2)
    - Mechanical brakes have levers or cables that force brake pads against the wheel (1)
    - Hydraulic brakes use brake fluid to apply brake pressure to the pads (1)

2. There are two key types of mounts in hydraulic brakes. What are the two types? Next, name two ways in which they differ from one another. (3)
    - Disc brakes (1/2) and drum brakes (1/2)
    - Disc brakes – press pads inward against the disc (1/2) and are on the front wheels (1/2)
    - Drum brakes – shoes press outwards against the drum (1/2) and are on the rear wheels (1/2)

3. Are air brakes more similar to mechanical brakes or hydraulic brakes? Why? (2)
    - Hydraulic brakes (1)
    - Both air brakes and hydraulic brakes rely on pistons to apply brake pressure OR both have disk and drum brakes (1)

4. Train brakes and bicycle brakes rely on different systems to function. In what way are the two systems fundamentally different, and in what way are they similar? (3)
    - Train brakes are air brakes (1/2) and use compressed air to press brake shoes against the wheel (1/2)
    - Bicycle brakes are mechanical brakes (caliper brakes) (1/2) when a rider squeezes the brake lever, force on the cable presses the pad against the wheel (1/2)
    - Both press pads against the outside of the wheel (1)

APPENDIX D

Demographic Questionnaire

What is your gender?

a. Male
b. Female
c. Prefer not to respond
d. Other (please specify):_____

What is your age (in years)? _____years

APPENDIX E

Multi-Media Comprehension Battery (Gernsbacher & Varner, 1988)

STORY 1: MIKE HOOTER AND THE SMART BEARS IN MISSISSIPPI

There are two kinds of bears - smart bears and foolish bears. Folks in Mississippi used to say
Mississippi bears were the smartest in the whole U.S.A.

That's what Mike Hooter, the great Bear-Hunter and Preacher of the Magnolia State, used to say when he was alive, and he sure knew all anybody ever knew about bears. Fact is, he was the greatest bear hunter ever was in Mississippi.

Some folks called him Mike Shouter, for he was forever roaring louder than ten waterfalls when he was preaching sermons or when he was arguing about the smartness of the Mississippi bears. Whenever anyone tried to argue about bears, Mike would tell them about Ike Hamberlin and his time with the smart bears.

One time Mike Hooter and Ike Hamberlin were talking about bears and they decided to go out hunting together. But Ike was monstrously jealous of Mike, so he thought he'd get a head start and go out alone before him. He set out in the early morning, just he and his dogs.

Well, Mike caught wind of this, so he got up early himself that morning, took his two-shooter, and went off looking for Ike. But Mike didn't take his dogs.

After a time he spotted Ike and just followed him for a distance. Ike had gone pretty deep into the woods when his dogs started growling and barking. They heard another kind of deep noise and their hairs stood straight up their backs like tomcats in a fight.

"Run go get 'em," Ike shouted to the dogs. But the dogs wouldn't. They just ran around Ike yapping and crying, as if they were scared to death.

"Sic 'em! Sic 'em!" Ike kept on hollering to the dogs, but they minded him like birds in flight.

Mike was watching all the time, wondering what was going to happen next.

Ike was mad as a hornet, but he was trying to keep his temper, he just kept coaxing the dogs to stir up the bear that he knew was in there somewhere. Those dogs just weren't acting natural. Mike was watching, and he even felt kind of sorry for Ike.

After all, there was the man out hunting for bear. And there was a bear just waiting to be got. And there were the bear-hunting dogs who were supposed to be stirring up the bear. But instead of doing their duty as good hunting dogs should, they just kept whining and

standing there with their tails between their legs. It sure wasn't right. You'd think a curse had been cast on them.

Ike was fit to be tied. "I'll teach you good-for-nothin' critters to tend to your business as you ought to," he shouted. Then he took his single barrel, leaned it against a tree, and ran to the creek. There he began picking up stones and throwing them at his dogs. Those dogs started howling to the heavens.

Just then Ike ran out of stones so he turned around to gather some more. As his back was turned, and his dogs were still howling up a storm, there was a sudden crackling and breaking sound coming from the woods. Mike was watching and out came the biggest and most powerful bear he'd ever seen. Ike heard the sound too and figured he must have thrown enough rocks for his bewitched dogs to get on with their business.

So Ike started setting down the stones he wouldn't be needing. But meanwhile this big mean bear had walked clear over to the tree where Ike had sat down his gun. The bear picked it up with his front paws and looked at it. Then he blew into it with some powerful breaths.

Ike turned around just in time to see the bear with his paws on the gun. Ike froze in his boots. His hair stood up on his head, his mouth was wide open, and his eyes were ready to jump out of his head. And Mike, watching, was just as numb.

The bear looked at Ike with a bear grin, then he put the rifle back against the tree, turned around, and walked off.

Ike rushed up to the gun, grabbed it, aimed straight at the bear, and snapped the lock!...But not a sound came from the trusty old piece. Though there was a sound of laughing afar off. Just then Ike looked down at his feet and sure enough he was standing in a pile of gunpowder.

Mike who had been laughing so hard decided it was time to give himself up. So he went out from his hiding place and told his friend what that smart Mississippi bear had done to his gun. Old Ike didn't think it was quite so funny. But after years of hearing Mike tell the story, Ike would laugh just as hard as any of the other listeners. And he'd laugh particularly hard when Mike would tell the part about when the bear was walking off, and how he stopped to look back at Ike standing there with that good for nothing gun, with his good for nothing dogs, and how the bear then put one of his front paws up to his face, and thumbed his nose at poor ole Ike.

Story 1 Questions

1. According to the story, what two kinds of bears are there?
2. What was Ike’s last name?
3. What did the bear do to Ike’s gun?
4. What did Ike do to try to get his dogs to obey?

5. What else was Mike besides a bear hunter?
6. What might an onlooker think had made the dogs act so strange?
7. How loud did Mike Hooter, known as “Mike Shouter” shout?
8. The story said that Ike was as mad as a what?
9. When Ike’s dogs weren’t behaving properly, how did Mike feel?
10. Who had the better gun—Mike or Ike?
11. By what state nickname did the storyteller refer to Mississippi?
12. According to the story, how did the bear make fun of Ike?

STORY 2: THE HUSBAND WHO WAS TO TAKE CARE OF THE HOUSE

Once upon a time there was a man who was very hard to please and who never thought his wife did anything right around the house. One evening, during the harvest season, he came home, scolding and swearing and making a fuss as usual.

"Dear love, I wish you weren't always so angry with the way I keep the house. I try to do my best at this job, but I never can please you" his wife said. "I know, tomorrow, let's change jobs. I'll go out with the harvesters and harvest the hay and you stay home and take care of the house."

The husband thought that might be a pretty good idea. And he said he was willing to try it.

So, early the next morning, his wife took his scythe, placed it around her neck, and went out to the hay field with the rest of the harvesters. Meanwhile her husband was to care for the house and do the work she usually did; only, of course, he was to do it much better and more to his own liking.

The first thing he needed to do was churn some butter, but after he had churned for a while, he got thirsty. So he went down to the cellar to tap a barrel of ale. Just as he placed his mug under the tap and turned it on, he heard overhead their pig wandering around in the kitchen. So he ran up the cellar stairs as fast as he could to make sure the pig wouldn't upset the churn. As he got upstairs he saw that the pig had already knocked it over and was rolling and grunting in the cream. The man got so wild with rage that he forgot all about what he had started downstairs and began running toward the pig as fast as he could. He caught it outside and gave it such a swift kick that poor piggy fell dead on the spot. Then all at once he remembered about the barrel downstairs. But when he got back down to the cellar, the barrel was empty; but the cellar floor was full.

He tried to clean up the mess, but got frustrated and also remembered he still needed to churn some butter. So, he went into the dairy and found enough cream left to fill the churn again.

After he had churned for awhile, he remembered that their milking cow was still shut up in the barn and hadn't had a bite to eat or a drop to drink, and it was now mid-morning. As he thought about the cow he also thought that it was such a far trip down to the meadow. Then he got an idea: Instead of going to the meadow he could just get her up on the roof. After all, between the cracks in their roof grass had started to grow. This would be a way to get rid of it.

Now their house was at the top of a very steep hill so he thought he could lay a plank of wood from the ground to the roof and just let the cow walk right on up there. Sure enough, he found a plank, and the cow walked right on up.

Once back inside the house he remembered that the cow would probably need something to drink now that it was grazing. To get some water, he'd have to walk down to the well. But, by this time their baby had awoken from her nap and she was playing in the other room. So, he thought he surely couldn't leave the churn unattended: the baby might crawl into the kitchen and upset it. He decided he'd just have to take the churn with him. So, he put it on his back, grabbed a bucket and left the house.

When he got to the well, he stopped and leaned over to fill his bucket. But when he did, all the cream ran out of the churn all over his shoulders and down into the well.

Now it was getting close to noon and he knew his wife would be ready for her lunch. But he didn't even have any butter churned yet. So he thought that the best thing to do was to start boiling the porridge. He filled a pot with water and hung it over the fire. When he had done that, a terrible thought ran through his mind: What if the cow fell off the roof, and broke her neck?

So he decided he'd have to go up there and tie her down. He attached one end of a rope to the cow's neck, and the other end he dropped down the chimney. Once back down in the kitchen, he tied the second end to his own thigh. Meanwhile, the water was starting to boil and he still had to grind the oatmeal.

So he began to grind away, but while he was hard at it, the cow lost her balance and fell off the roof. And, as she fell she dragged the man up. He got stuck about halfway up the chimney, and the cow hung halfway down.

Out in the hay field, the wife had waited nearly two hours for her husband to come call her in for lunch. Finally, after waiting a half-hour more, she headed for the house. When she got there she saw the cow hanging in mid-air. The wife felt sorry for her. So she cut the rope with her scythe. As she did, down came her husband. So, walking into the kitchen, she saw her husband - who was to take care of the house - with his head inside the porridge pot.

Story 2 Questions

1. Starting his housework, what was the first thing the husband tried to do?
2. What crop were they harvesting in the field?
3. What was in the barrel in the cellar?
4. What two ways did the cream get spilled?
5. Whose idea was it for the husband and wife to change roles?
6. Why did the husband run up the cellar steps?
7. What kind of porridge were they supposed to have for lunch?
8. How long (in all) did the wife wait to be called in for lunch?
9. How did the wife carry the scythe?
10. When tying the cow down on the roof, why did the man have to hurry?
11. What part of his body did the husband tie the rope to?
12. Where in the house was the fireplace located?

STORY 3: THE MOST PRECIOUS POSSESSION

There was a time when Italian traders and explorers were blocked in their way to the East by the Turks. So, the Italians turned west in their search for new lands to trade with.

In those days there lived in Florence a merchant named Ansaldo. He belonged to the Ormanini family, a family known not only for its wealth but for its daring and cunning young men. On one of his trips in search of adventure and trade, Ansaldo ventured beyond the Strait of Gibraltar and, after battling a terrible storm, landed on one of the Canary Islands.

The king of the island welcomed Ansaldo with open arms and ordered a magnificent banquet to be prepared and served in an elegant hall decorated with mirrors and gold.

At dinner time, Ansaldo noticed with surprise that a small army of youths carrying long thick sticks, entered and lined up against the walls of the banquet hall. As each guest sat down, one of the youths took a place directly behind him, with his stick held ready.

Ansaldo wondered what all this meant. He didn't have long to wait before he found out. For suddenly, troops of huge ferocious rats poured into the hall and threw themselves upon the food that was being served. All hell broke loose as the boys ran from here to there, swinging their sticks.

For many years the Florentines had enjoyed a reputation for being the most clever people on earth and able to cope with any situation. Ansaldo saw a chance to uphold that tradition. He asked the king's permission to go back to his ship, and returned shortly with two big Persian cats, for one or two cats always joined the crew of a ship whenever it set out on a long journey.

Ansaldo let the cats go and before long the entire hall was cleared of the rats.

The king thought he was witnessing a miracle. He could not find words enough to thank Ansaldo. The king hailed Ansaldo the savior of the island, and when Ansaldo gave the cats to the king for a present, the king's gratitude was overwhelming.

Ansaldo soon got ready to sail for home. The king accompanied him to his ship and there he showered him with rich and rare gifts. He gave him great quantities of gold, silver, and many precious stones of all kinds and colors, rubies, topazes, and diamonds.

When Ansaldo returned home he thrilled his friends with the account of his strange adventure. Among his friends was a certain Georgio Fiffanti. Georgio was as rich in envy as he was poor in intelligence. He thought: "If the king gave Ansaldo all those gifts for two silly cats, what won't he give me if I present him with the most beautiful and precious things that our city has to offer?" No sooner said than done, Giorgio had purchased lovely belts, necklaces, luxurious garments and many other expensive gifts and had set out on a ship for the Canary Islands.

Georgio arrived in port and hurried to the royal palace. The king was greatly touched by the lovely gifts and wanted to be equally generous. He held a long consultation with his people and then informed Georgio happily that his people had decided to let him share their most precious possession with Georgio.

The date to depart finally arrived and there was Georgio waiting impatiently on his ship for the king's farewell visit. Before long, the king, accompanied by the entire royal household and half the islanders, approached Georgio's ship. The king himself carried the precious gift on a silk pillow. With great pride he put the pillow into Georgio's greedy outstretched hands. Georgio was speechless. On the pillow, curled up in sleepy, furry balls, were two kittens.

Story 3 Questions

1. What was always carried aboard each Florentine ship on a long journey?
2. Why did the youths hold the stick in the dining hall?
3. What personality trait was Georgio “rich” with?
4. What three kinds of precious stones did the king give to Ansaldo?
5. What breed of cat did Ansaldo give the king?
6. Were the people of the Canary Islands poor?
7. Who accompanied the king when he gave his gift to Georgio?
8. Who blocked the Italian traders’ way to the East?
9. How did the king feel about Georgio’s lovely gifts?
10. What did the king think when the cats cleared the dining hall?
11. How was the king’s gift to Georgio “wrapped?”
12. What reputation did the Florentines have around the world?

STORY 4: THE HONEY GATHERER'S THREE SONS

A honey gatherer had three sons, all born at the same time. Their names were Hear-it-however-faint-the-sound, Follow-it-however-great-the-distance and Put-it-together-however-small-the-pieces. These names are sufficient to indicate the skill of these young men, but their friends simply called them Hear, Follow, and Piece.

One day the honey gatherer went on a long, long journey into the forest until he came to a tree that was as high as a hill, and the bees that buzzed in and out showed clearly that it must be full of honey. He climbed up, but, balancing on a rotten branch, fell to the ground and was broken into ten pieces.

Hear was sitting beside the hut in the village, but he promptly jumped to his feet, saying, "Father has fallen from a tree. Come! Let us go to his help."

His brother Follow set out and led them along the father's tracks until they came upon the body lying in ten pieces. Piece then put all the parts together, and fastened them up. Later, father then walked home while the sons carried his honey.

Next day, the honey gatherer again set out to look for honey, while his sons sat at home, each boasting that he was more important than the others.

"You could not have heard him without me," said Hear.

"Though you had heard him you could not have found him without me," said Follow.

"Even though you had found him, you could not have put him together without me," said Piece.

Meanwhile the old honey gatherer had gone far into the forest until he came to a tree that was as high as the clouds, and the bees buzzing in and out showed clearly that it must be full of honey. He climbed up, but he stepped on a rotten branch and it broke. The honey gatherer fell to the ground and was broken into ninety-nine pieces. His sons were sitting at home boasting about their individual skills, when Hear jumped up, saying, "Father has fallen!"

Follow reluctantly set out to follow the footprints, and found the ninety-nine pieces on the ground. Pointing to them he said, "See how indispensable I am. I have found him for you."

Piece then put the ninety-nine pieces together very grudgingly, saying, "I, and I alone, have restored Father."

Their father walked home, while the sons carried the honey.

The next day the old honey gatherer went farther than ever into the forest and he found a tree that reached to the stars. The bees buzzing in and out showed that it must be full of honey. He climbed up, but treading on a rotten branch, fell to the ground and was broken into a thousand and one pieces.

Hear heard the fall, but would not tell his brothers. Follow knew that there must have been an accident since his father did not return, while Piece realized that his father needed his assistance, but would not ask his brothers to find him so that he might piece him together.

So the old honey gatherer died, because his selfish sons each thought more of his own reputation than of his father's. In truth, each needed the others, and none was wiser or better than the rest.

Story 4 Questions

1. How many pieces did the honey gatherer break into the third time he fell?
2. Who always carried the honey home?
3. How did Follow find his father whenever he fell?
4. How many pieces did the honey gatherer fall into the second time he fell?
5. Which of the three sons was the oldest?
6. How many pieces did the honey gatherer fall into the first time he fell?
7. What were the songs doing the second time their father fell?
8. How tall was the third tree the honey gatherer fell out of?
9. Why did the honey gatherer fall out of the first tree?
10. How tall was the second tree the honey gatherer fell out of?
11. The third time the honey gatherer fell, how did Follow know about it?
12. What were the full names of each of the three sons?

CURRICULUM VITAE

Kyle J. St. Hilaire

June, 2017

Education

Exp. 2022	Ph.D. in Psychology; Iowa State University Ames, Iowa
2017	M.A. in Psychology; Wake Forest University Winston Salem, North Carolina
2015	B.S. in Psychology; Furman University, Cum Laude Greenville, South Carolina

Professional Experience

Research Experience

2015-	Cognitive psychology research on the learning benefits of test-taking; Advisor: Dr. Janine M. Jennings
2014-2015	Cognitive psychology research on prospective memory mechanisms; Advisor: Dr. Gilles O. Einstein
2013-2014	Clinical Psychology Research on older adults' health perceptions; Advisor: Dr. Kerstin B. Blomquist

Teaching Assistantship

2015-2017	Exam grading; Essay grading; Exam proctoring; Guest lecturing Teaching assistant for Cognitive Psychology, Introductory Psychology, Psychopharmacology, Developmental Psychology, and Abnormal Psychology

Academic Awards and Scholarships

2017	Presidential Scholarship; $49,764; *Iowa State University*
2016	Graduate Summer Research Support; $1,000; *Wake Forest University*
2015-2017	Graduate Assistantship; $93,190; *Wake Forest University*
2014	Furman Advantage Summer Funding Scholarship; $3,000; *Furman University*
2013	Furman Advantage Summer Funding Scholarship; $3,000; *Furman University*
2011-2015	Academic Achievement Scholarship; $16,000 annual; *Furman University*

Research in Progress

St. Hilaire, K. J. & Jennings, J. M. Enhancing the pretesting effect: The benefit of open-ended pretest questions

Blomquist, K. B., Horhota, M., **St. Hilaire, K. J.**, & Short, M. A. Food cultures and aging: An examination of older adults' food perceptions and the transmission of this knowledge to younger generations.

Conference Posters

St. Hilaire, K. J., Blumenthal, S. A., Butkevits, N. M., Geiger, O. J., Fisenne, S. E., & Jennings, J. M. (accepted). *The pre-testing effect: A limited efficacy learning technique?* Poster presented at the annual meeting of the Psychonomic Society, Boston, Massachusetts.

Short, M. A., Horhota, M., Blomquist, K. K., & **St. Hilaire, K. J.** (2015). *Food, culture, and aging: An examination of older adults' knowledge about healthy eating behaviors.* Poster presented at the Gerontology Society of America Annual Conference, Orlando, Florida.

St. Hilaire, K. J. & Einstein, G. O. (2015). *Prospective memory: Do related cues cause intentions to pop into mind?* Poster presented at Furman Engaged!, Greenville, South Carolina.

St. Hilaire, K. J., Short, M. A., Blomquist, K. K., & Horhota, M. (2014). *Food cultures and aging: An examination of older adults' food perceptions and the transmission of this knowledge to younger generations.* Poster presented at Furman Engaged!, Greenville, South Carolina.

Professional Memberships

2016-	Psychonomic Society
2015-	American Psychological Association
2015-	Psi Chi Honor Society in Psychology