Spring 2009

Influence of Pictures on Word Recognition

Audrey A. Hazamy
Georgia Southern University

The Influence of Pictures on Word Recognition

by

AUDREY A. HAZAMY

(Under the Direction of Lawrence Locker)

ABSTRACT

The picture superiority effect is a well-documented phenomenon that is defined as the superior memory of pictorial stimuli compared to word stimuli. The predominant explanation for this effect is that pictures are encoded more effectively than words, and are therefore able to be better remembered. Research has demonstrated the benefit that pictures provide for remembering words. However, little work has been to done to examine any negative and/or intrusion effects of pictures on memory for words. The current study further explored the picture superiority effect and facilitation effects of pictures on words as well as interference effects of pictures on word memory. Results indicated that matching and semantically related pictures facilitated word recognition memory. Incongruent/unmatching pictures however were of no detriment. Implications of picture processing and pictorial influence on word processing are discussed.

INDEX WORDS: Picture superiority, Picture and word processing, Picture processing, Picture intrusion, Picture interference, Picture facilitation, Semantic relatedness, Word processing

The Influence of Pictures on Word Recognition

by

AUDREY A. HAZAMY

B.A., Florida Atlantic University, 2007

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

2009

The Influence of Pictures on Word Recognition

by

AUDREY A. HAZAMY

Major Professor: Lawrence Locker
Committee: Karen Z. Naufel
John D. Murray

Electronic Version Approved:
May 2009

ACKNOWLEDGMENTS

I would like to acknowledge the advice, direction, and support of Dr. Lawrence Locker, committee chairman. I also thank the members of my graduate committee, Dr. Karen Z. Naufel and Dr. John D. Murray for their guidance, suggestions, and encouragement throughout this process.

TABLE OF CONTENTS

Page

CHAPTER 1

INTRODUCTION

Psychologists have expansively studied the differences between the encoding and processing of words and pictures. Perhaps one of the most extensively investigated of these differences is known as the picture superiority effect, which is the finding that items presented in picture format are better remembered than those presented in word formats (Nelson, Reed, & Walling, 1976; Stenberg, Radenborg & Hedman, 1995). Many differing perspectives have emerged over the years as to the source of this effect. Although diverse in their approaches and explanations, the superior processing nature of pictures is the primary tenet of these various theories. Due to their encoding benefit, pictures are utilized in numerous instances such as teaching sight vocabulary, and pairing pictures with words and text to provide clarity to overall meaning. The beneficial aspects of using pictures with words and texts, and the superior nature of picture processing are well replicated and are demonstrated throughout the literature (e.g., Nelson et al.; Waddill & McDaniel, 1992; Stenberg et al). A review of the literature investigating the phenomenon provides well-documented explanations of the mechanisms behind the facilitative nature of pictures on word encoding. However, it also reveals a paucity of research regarding the potential intrusion of pictures on word processing and memory. Intrusion effects of pictures would be a vital key to understanding how pictures influence word processing and how pictures themselves are processed differently than words. Research concerning intrusion effects of pictures on word processing will potentially allow for the more effective use of pictures in some instances, and the ability to recognize when it may not be beneficial to implement their use.

When Pictures Facilitate Memory

Dual-coding Hypothesis. Perhaps the most well-known explanation for the picture superiority effect is the *dual-coding hypothesis* (Paivio, 1969; 1971). Dual coding has been the basis of numerous theories and debates regarding picture superiority. The hypothesis states that pictures and words are processed differently such that pictorial information is stored dually (visually as well as acoustically), whereas words are stored via only an acoustic/verbal store and thus only in one form (Paivio, 1971; Pellegrino, Siegel & Dhawan, 1975; Snodgrass & McClure 1975; Nelson et al., 1976; Mintzer & Snodgrass, 1999).

To demonstrate support for the dual-coding hypothesis Jenkins, Neale and Deno (1967) compared the recognition of pictures and words. Jenkins et al. presented participants either pictures or words and then tested recognition memory using either the same or the alternate format. That is, words or pictures were presented in a study condition and then recognition was tested using either the word or the picture representation of the word. The picture-word condition revealed highly similar results to the word-word condition, suggesting that the pictures are stored using a verbal representation in addition to a visual store. The greatest difficulty in correctly identifying the original stimuli was observed for participants in the word-picture condition. This difficulty is also indicative of the idea that words are not encoded using a visual form, but rather only via a verbal form.

Pellegrino et al. (1975) also provided support for the dual code hypothesis by examining short-term retention of pictures and concrete words. Pellegrino et al. used auditory and visual distraction in an attempt to interfere with the encoding and retention of a picture or presented word. Auditory distraction was created by having participants count backward out-loud by 13. The visual distraction required participants to perform a visual search task to find a shape within

a matrix of lines (known as the hidden figures task). Auditory distraction led to better retention for pictures than words, presumably due to the additional visual store associated with pictures. Visual distraction was not associated with detriment for pictures compared to words. These results were presumably due to the acoustic store that both possessed. Picture memory could be based on an acoustic store, thus leading to no detriment compared to words. However, the use of both visual and acoustic distraction produced a significant decline in picture memory, below that of the decline in participants' word memory, providing support for the idea that pictures are dually encoded (Pellegrino et al.).

Snodgrass and McClure (1975) explored the *dual-code hypothesis* by instructing participants to manipulate the type of encoding used for words and pictures. Participants verbally rehearsed items, or rehearsed items using visual imagery. Participants in either of the picture recognition conditions, (i.e., verbal rehearsal or rehearsal using imagery) showed no difference in recognition accuracy. Thus, memory for pictures was not influenced by the instructions given. There was however a significant difference in the word conditions. Words rehearsed using the imagery strategy were better remembered than those that were repeated using the verbal rehearsal strategy, suggesting acoustic storage is the default (as discussed by Jenkins et al., 1967) unless otherwise instructed. These results indicated that pictures are dual coded automatically whereas words are only dual coded when participants are initiated to do so.

A dual coding view for vocabulary learning was provided by Sadoski (2005). He suggested that the dual coding theory provides a dominant framework for effective vocabulary learning in children. One study noted in Sadoski's work by Arlin, Scott and Webster (1978, 1979), examined the effectiveness of using pictures, auditory pronunciation, or no alternate method in conjunction with the printed word form when children are learning sight vocabulary.

Overwhelmingly, the children who were presented pictures in combination with the printed word form acquired the sight vocabulary significantly faster than those in the other conditions. Taking into account this and other previous research, Sadoski concluded that children provided with pictures when learning concrete words are better able to learn the words than children who are not provided with a picture complement. According to Sadoski, these findings support the dual code theory that pictures are encoded both non-verbally and verbally. With the use of pictures, the meaning of the word is expanded beyond plain text recognition and processed along more than a single acoustic store as would be the case if words were presented without a picture. Thus, the pairing of pictures with words helps establish multiple connections between the verbal and non-verbal representation of a word. The dual coding effects of pictures presented with a visual label of a word allows for better vocabulary acquisition when children are learning to sight-read. Numerous studies such as those mentioned above have provided strong support for Paivio's (1969, 1971) *dual-code hypothesis*. However, other perspectives have also been proposed that provide differing and alternate explanations for the picture superiority effect.

Alternative Explanations. Researchers have proposed the sensory-semantic model of picture superiority that states that rather than being processed along dual stores, pictures are processed along a single store, although this single store is qualitatively superior in nature to that of word stores (Nelson et al., 1976). Essentially, pictures provide qualitatively superior sensory information for coding than do words, and are thus easily processed and encoded into memory. In their study, Nelson et al. hypothesized that the picture superiority effect might be reversed by the same sensory codes that normally lead to an advantage. They demonstrated this by providing participants a list of words or pictures then manipulated the pictures' conceptual and schematic similarities. For example, pictures appeared similar or different to one another in terms of

configuration and shape, making them less or more distinguishable from one another. Participants least remembered pictures with high degrees of conceptual and schematic similarities with other pictures on the list, even compared to word memory. The lack of distinctiveness between pictures supposedly neutralized the superior sensory code and thus resulted in more errors. However, when conceptual and schematic similarities between pictures were low (i.e. pictures were easily distinguished from one another), the picture superiority effect remained. Thus it can be concluded from this research, that rather than being encoded in two forms as the *dual-code hypothesis* states, pictures may be better remembered because they provide participants with more distinguishable and qualitatively superior perceptual encoding information than do words.

In addition to the sensory-semantic model, Nelson and Reed (1976) also incorporated a levels of processing (Craik & Lockhart, 1972) component into their explanation of the generally superior memory for pictures over their verbal labels. According to Nelson and Reed, pictures are not automatically given a verbal label, as suggested by the dual code hypothesis, but rather the extent of verbal labeling is controlled by the learner. The learner may apply a label to a picture if the situation calls for a label, such as in order to assist in the processing and storage of the stimuli. However, in order to convey the meaning of a picture, a verbal label need not be applied and thus the application of a label is not necessarily spontaneous. A level of processing theory may be more applicable rather than a dual coding strategy, as pictures were not given word labels by participants on all trials (Nelson & Reed, 1976). Instead, it was suggested that the picture-superiority effect may more likely be a result of qualitative differences at the sensory level in which pictures provide a better mnemonic representation and subsequently lead to a deeper level of processing than that of their word labels.

Alternatively, Stenberg et al. (1995) offer a common code theory of semantic activation in which semantic links provide pictures their superior advantage to verbal labels. According to their theory, pictures activate semantic links better than verbal labels, implying that pictures are superior in activating memory cues than words. Stenberg et al. provided participants pictures and words to study in an initial task and then tested their memory using a subsequent memory task. Not surprisingly, results revealed that accuracy and reaction times were both faster for picture stimuli than for the words. Using cross-modal priming, in which words are primed using pictures and vice versa, they also found that words that were primed using their picture form were better recognized than pictures that were primed using their word form. From these results, it was concluded that processing of pictures may prime and activate analogous semantic nodes more so than do words. These additional semantic links activated during processing may aid retrieval during a subsequent search during a memory test. These results support a privileged, semantic based access model for picture superiority, in which pictures lead to superior semantic encoding.

Others have offered another comprehensive argument against the *dual-code hypothesis*. Implementing the form-change paradigm (see Jenkins et al., 1967) in which pictures and words are studied and then tested using their same or alternate form, Mintzer and Snodgrass (1999) provided support for the distinctiveness model of picture superiority. The most prominent component of the distinctiveness model states that pictures have highly distinctive semantic and sensory features that make them highly distinguishable from one another and from words. Words, however, do not have such features. Support for the theory was demonstrated in that pictures that were studied and presented as pictures showed the best recognition memory, supposedly due to their mnemonic superiority compared to words. A form-change cost is the difference in recognition memory performance between items studied and tested in the same

form and items studied and tested using their alternate form. In addition to the finding that pictures presented in the recognition task as pictures best facilitated participants' performance, the study also found that pictures had a much more significant form-change cost to the participant's recognition memory than did words. That is participants' performed worst when pictures were presented in the recognition task as words. According to the model, this form-change cost occurs because the pictures loose their mnemonic edge over words (Mintzer & Snodgrass). Also, because pictures had the greatest form-change cost, results were inconsistent with the idea that the pictures are dual encoded, as a verbal code was apparently not evoked for the pictures. Rather, much like the theories of Nelson et al., (1976) and Stenberg et al., (1995), Mintzer and Snodgrass suggest that the superior memory for pictures is due to their distinctive sensory and semantic properties and not due to an additional verbal store.

Stenberg (2006) provided further insight into how conceptual and perceptual aspects of pictures may provide pictures with their superiority over words. While conceptual factors such as semantic meaning and perceptual aspects such as discriminating sensory details were investigated before (as described above), Stenberg attempted to distinguish which of the two factors played a more significant role in the superiority effect. Using orientating tasks and encoding manipulation, participants were directed toward more conceptual or perceptual processing of the pictures and words during a study task. Results indicated that although perceptual form based processing played a role in picture processing, there was a large difference between conceptual based and perceptual based processing. The results favored the notion that a larger contribution to the picture superiority effect is that of conceptual meaning based processing.

As these studies demonstrate, the majority of the alternatives to the dual coding hypothesis emphasize semantic and distinctiveness explanations of the effect. However, all the studies described above, although having slightly differing perspectives on the picture superiority phenomenon, provide overwhelming support for the notion that pictures are better processed and encoded relative to words.

Facilitative Applications of Pictures

Thus far, the literature has largely discussed the nature and hypotheses behind the picture superiority effect. I will now turn to the applicability and facilitative nature of using pictures/illustrations in conjunction with words. A great deal of research has been conducted that explores how pictures facilitate learning and text/word comprehension. Waddill, McDaniel and Einstein (1988) examined whether the type of text (either narrative or expository) and the type of picture presented with the text (either detail or relational) would influence memory for the text. It is presumed that pictures primarily serve a supplementary function in that they reinforce the information provided via text. In their study, participants were presented either a fairy tale (narrative) or an expository text (i.e., texts that aim to explain something such as the information found in an encyclopedia) in conjunction with detail information (e.g., illustrations that portray a specific detail of a proposition), relational information (e.g., illustrations that connected ideas and causal relationships of many propositions) pictures or no pictures. In some cases, participants were directly instructed to attend to the pictures, while in others participants were not. The latter case allowed for incidental learning. Results indicated that when no instruction was given to a participant to attend to the pictures, the pictures served only to reinforce the important target information provided in the text. That is, only target information was better remembered. Additionally, pictures only increased free recall when the picture was designed to

depict the specific type of information the text presumably invited. Expository texts are presumed to elicit more individual-item processing (detail) and narratives are presumed to elicit relational processing (Waddill et al.). Thus, recall of detailed information was only significantly better for expository text and recall of relational information was better for the fairy tale condition. However, when instruction guided participants to pay particular attention to the pictures, they served not only to reinforce the target detail and relational information regardless of the condition, but also directed attention to non-target information. Thus, pictures do appear to support text processing, although the nature of the facilitation varies depending on differing conditions.

In a follow-up study, Waddill and McDaniel (1992) again examined the pictorial enhancement effects on detail and relational information within text. They analyzed the facilitative effects of pairing pictures with text by providing participants expository text with loose conceptual coherence or with explicit conceptual relationships. The use of explicit conceptual relationships in text conveyed ideas and connections more overtly by using phrases such as “by contrast”, “more than” etc. For both types of text, results indicated that the types of illustrations paired with the text had an effect on the subsequent recall of the text. Recall of both relational information and detail information was significantly better in the group provided illustrations than those provided no illustration supplements regardless of text type, indicating that pictures enabled further processing than would occur had no pictures been present (Waddill & McDaniel). Likewise, in a study reported by Glenberg and Langston (1992), participants in one group were provided procedural texts accompanied by appropriate illustrations and participants in the other group were presented with lone text. During a speeded test, participants had to respond "yes" or "no" in reference to questions about two steps in a procedure (e.g.,

"Would the step containing the phrase on top immediately precede the step on the bottom […]" Glenberg & Langston). The speeded test was followed by true/false comprehension questions. The assumption was that if participants represented the procedure in a mental manner, they would more quickly and accurately answer questions about far pairs in a procedure (e.g., step 1 and 4) because in a mental representation of the procedure, the middle steps are strongly related to the preceding and succeeding steps equally. Participants provided with the text and appropriate pictures tended to represent the *procedure* mentally, rather than simply mentally representing the *text,* as was the case in the no picture condition. The results of the study suggest that pictures aid the comprehension of corresponding text, via building representative mental models and drawing inferences as to what the text was about.

The use of pictures at the time of encoding of associated words that converge onto a lure word can also reduce the later false recognition of words (Israel & Schacter, 1997). Based on the methodology of Roediger and McDermott (1995) in which participants often falsely recognize lure words related to words in a presentation list, Israel and Schacter introduced the use of pictures to the task of distinguishing semantically related words and lure words in a recognition task. Participants were presented words either in auditory form, or in both auditory and visual form. Additionally, participants were provided either pictorial enhancement in the form of a line drawing or no pictorial enhancement. The use of pictorial stimuli reduced the amount of false recognition in a subsequent memory task that included lure words as well as non-lure words and enhanced the ability of participants to correctly distinguish between old and new items in a recognition task list. Again, studies such as this support the usefulness of using the distinctive aspects of pictures.

Levin (1981) (as cited in Carney & Levin, 2002) perhaps provided the most comprehensive assertion of how pictures influence text processing in his proposed "five functions of pictures". The first of the five functions is the simple decorational function, in which pictures presented along side text are primarily for embellishment purposes. The second is the representational function in which pictures simply mirror text. A representational picture literally depicts the text it is accompanying and its purpose is to make the text more concrete to the reader. Third, organizational illustrations provide a structural framework for the text such as illustrations of a procedure a person would typically find in an instructional manual for how to put something together. Organizational pictures are useful when attempting to depict a series of steps. Interpretational pictures, such as those often found in science books clarify complicated and difficult text (e.g., biological processes). Finally, transformational pictures are systematic memory enhancing devices that are specifically designed to improve the recall of information (Carney & Levin, 2002). Often referred to as mnemonic pictures, Levin (1986) also found that transformational pictures assisted students in higher order cognitive application and applying problem solving skills to the text in question. Transformational pictures often use illustrations of keywords to prompt the memory of the reader, [e.g., the use of a bell to depict the name of a key city Belleview, (Dretzke, 1993 as cited in Carney & Levin)]. In summary, the use of pictures in conjunction with text provides participants with numerous processing and encoding advantages over the presentation of text alone. The five functions of illustrations indicate the numerous ways in which pictures can facilitate text comprehension as well as text recall.

Non-facilitative and Potential Intrusion Effects of Pictures

The literature discussed thus far has emphasized the superior memory for pictures over words and the facilitative nature of pairing pictures with words and text passages. Although a

primary purpose of this study is to further explore the facilitative nature of pictures on word memory, exploring the potential intrusive effects of pictures on word memory is also an important objective. However, there appears to be little prior work that discusses potential intrusion effects of pictures on the memory of words. Of the literature that has explored the possibility of negative effects of using pictures for verbal enhancement, the most widely discussed is the issue of using pictures in tandem with words when teaching children vocabulary. Some research suggests that pictures aid vocabulary learning (e.g., Sadoski, 2005; Goodman, 1965) and the use of picture enhancement is a generally accepted practice in schools when teaching children new sight words. However, as the following literature suggests, this common practice may not be an effective one. Singer, Samuels and Spiroff (1974) reported a study in which the use of pictures and contextual conditions supported the idea of Samuels (1967) focal attention theory. Samuel's focal attention theory states that the use of pictures and contextual cues are detrimental to the learning of words in new readers as they detract from the learning of the words graphic features (i.e. they distracted the learner from focusing attention to the word itself). Results of the study supported this notion in that children who were presented only words learned the words more efficiently than those who were provided pictorial or contextual cues. In a similar study, Solman and Singh (1992) investigated the effects of using pictorial enhancement when teaching children to read words. The children were presented four conditions: two simple conditions in which a word was presented alone, either in small print or in large print; two compound conditions in which pictures were presented with the word as either a line drawing above the word, or below the word. In contrast to studies that suggest pictures effectively facilitate the memory and learning of words (e.g., Sadoski; Arlin, Scott & Webster, 1978-1979 as cited in Sadoski, 2005; Goodman), children had better accuracy in naming the sight words in

both the simple word conditions than in either of the compound picture conditions. In a similar study, mentally retarded children acquired sight vocabulary faster when words were presented without pictorial enhancement or prompts (Singh & Solman, 1990). It was argued that blocking may be responsible for the hindrance pictures pose on written word acquisition. That is, a previously learned association of the picture and verbal response (verbal naming of the picture) may interfere with the learning of the written form of the word. In a sense, the old association of the picture and verbal response blocks the new association of the picture and written word.

In a comparable study, Conley et al. (2004) also examined the use of pictures in the acquisition, as well as the maintenance of sight words, in children learning to read. This study compared the use of the cover, copy, and compare (CCC) method to the use of the picture matching teaching method. The CCC method requires that the student cover a correct model of the word on one side of a page with an index card and then write the word in the space on the other side of the sheet. The student then uncovers the correct model and checks his/her work. In addition, students in the CCC group were instructed to trace the word before attempting to write it on their own. Students in the picture-matching condition were presented either a picture or a word card by the investigator and were asked to match the card with the corresponding picture or word card from a stack of their own. Although initial results suggested that the picture-matching approach required fewer sessions to acquire mastery of the vocabulary, further assessment indicated that in the CCC condition, word maintenance was ultimately higher than in the picture-matching condition. Additionally, Conley et al. found when the pictures were subsequently removed in the picture-matching condition, children began to misidentify the words, suggesting that in the picture-matching conditions children were picture reading and not word reading.

Overall, the outcomes suggest that the use of methods such as the CCC method may be more effective than picture-word methods.

Although the literature discussed in these studies identifies the problem of pairing pictures with words for children learning to read, to the author's knowledge, relatively little research has focused on the possible hindrance of pairing pictures with words in adult readers. However, pictorial intrusion effects on word processing have been investigated in the context of asking participants to make a particular judgment about a word in the presence of a distracting picture. Research has shown that one such judgment, the classification of words into categories, is affected by the presence of pictures (Smith & Magee, 1980, Arieh & Algom, 2002; Lupker & Katz, 1982). Smith and Magee conducted a study in which participants were asked to classify pictures and words in the presence of incongruent stimuli by making "yes" or "no" responses regarding whether the stimuli belonged to a specific category. Word categorization was found to be significantly delayed in the presence of distracting pictures. The categorization of pictures however was not affected by the presence of distracting words. Lupker and Katz also studied the phenomenon. Participants made category judgments regarding word stimuli in the presence of incongruent pictures. Participants were specifically asked to ignore the pictorial stimuli and simply respond "yes" or "no" as to whether the word stimuli fell into the category "animal". In a second experiment, participants made "yes" or "no" judgments as to whether the target word was the word "DOG". The researchers found that the incongruent background pictures interfered with the word judgments. Lupker and Katz, and Smith and Magee accounted for their results in terms of automatic semantic processing theory of pictures. That is pictures are automatically placed into semantic categories and allow faster semantic access than do words. Because the categorization tasks require the semantic analysis of a word, and because the incongruent

pictures are placed into semantic categories faster than are the words, the pictures intrude on word judgment. Based on the notion of automatic semantic picture processing, it can be concluded that in some contexts pictures that are incompatible with a correct word response can negatively influence word judgments. A similar argument made by Arieh and Algom (2002) suggested that pictures are categorized faster than are words and that word categorization suffers from intrusion by incongruent pictures. They also found that the influence and the amount of interference is largely subjected to contextual variations. Contextual changes (e.g., contrast changes between the print and background, reducing/increasing the size of pictures, and adding an x to the prefix and suffix of a word) in the stimuli served to reduce/eliminate or enhance the pictorial interference on word categorization. Thus, these results further complicate the issue of how pictures intrude on words in varying types of tasks.

Semantic Effects of Pictures on Words

The semantic intrusion effect of pictures (as demonstrated by the automatic semantic processing theory of pictures) on word judgments suggests that there is a potential for intrusion effects of semantically related pictures on word processing. Thus, in addition to addressing the interference of pictures on word encoding and retention, the present study will also attempt to investigate the effect of semantic relatedness of a picture on word memory. Although research supporting the automatic semantic processing theory examined effects of semantically related pictures on word judgments, no known research has been conducted to directly investigate the semantic relatedness of pictures on subsequent word memory. Research has however been directed to studying the effects of semantically related distractors on stimuli using the picture-word interference task. The picture-word interference task consists of presenting participants line-drawings and then asking participants to name the picture in the presence of a distractor

word. On the whole, research overwhelmingly suggests that the use of words as distractors using the picture-word naming task slows response time in the naming of the target pictures (Smith & Magee, 1980). More importantly to this study, a great deal of research has also been conducted that explores the effects of different types of words (i.e., semantically related) on picture naming (Rosinski, 1977; Caramazza & Costa, 2000; Costa, Alario & Caramazza, 2005; Damian & Bowers, 2003 and Mahon et al., 2007). For example, using both children and adult groups, Rosinski demonstrated semantic interference in the picture-word interference task. Participants were presented pictures in the context of distractor words and were asked to verbally label the picture while ignoring the word distractor. The words were either congruent with the picture label, a consonant-vowel-consonant trigram, a semantically related word within the same category as the picture (e.g., the word "lion" presented on a picture of a pig) or a non-congruent word (e.g., the word "cup" presented on the picture of a pig). The same overall effect was noted in all age groups; semantically related words produced a larger amount of interference to picture naming than did un-related words and non-sense trigrams, suggesting that the semantic relatedness of the distractor plays a role in the ability to verbally name pictures in the interference task. Numerous other researchers have also concluded, as did Rosinski, that semantically related distractors from the same semantic category leads to pronounced interference effects, and thus the semantic relatedness of a distractor affects the magnitude of interference in the picture-word interference task (Costa, et al., 2005).

Along the same lines, Vitkovitch and Tyrrell (1999) discussed the effects of distractor words on the subordinate name retrieval of a picture. The picture-name interference task often focuses on basic level naming of a picture (e.g., dog) whereas this study focused on the subordinate naming or more specific naming (e.g., poodle) of an object. Participants were

presented picture and word conditions in which the distractor word was semantically related, unrelated or neutral in regard to the picture stimulus. Results revealed that when pictures were paired with subordinate distractor words that were from the same basic-level category (e.g., picture of a poodle and the distractor word spaniel) or semantically related basic-level category (e.g., picture of a poodle and the word koala) as the target picture, subordinate naming latencies were longer than unrelated or neutral words. The results support the notion that there is a semantic relatedness interference effect. That is, semantic relatedness of a word from the same or related basic-level category of a target picture can produce semantic interference/competition in subordinate picture naming (Vitkovitch & Tyrrell).

Based on the research discussed above, the interference produced by semantically related information had been termed the semantic interference effect. More specifically, it refers to the notion that participants are slower to name a picture of an object in the presence of a semantically related distractor than in the presence of an unrelated one. Perhaps the most prominent hypothesis behind the interference effect is the notion of lexical selection by competition/conflict. The main premise behind the lexical selection by competition is that given a picture (e.g., car) and a semantically related distractor (e.g., truck) or an unrelated distractor (e.g., hat), the semantically related distractor activates more semantically related lexical nodes to the target than does the unrelated distractor. The simultaneous activation of the related lexical nodes, in addition to the activation of the target node is thought to create competition in the retrieval process and may be the source of the interference in the picture-naming task (Costa et al., 2005; Mahon et al., 2007, Damian & Bowers, 2003).

Given the research discussed above, the question then becomes whether the same intrusion effects are observed in which the processing of semantically related pictures interferes

with the processing of a target word. As mentioned, the direction of the reverse effect, that of picture interference on word naming has been less researched and defined than that of the word intrusion effect, and thus there is debate regarding whether there is an intrusion of pictures on word naming. Smith and Magee (1980) did note that most research thus far suggests that the naming of words in the presence of incongruent pictures is relatively un-affected, perhaps due to the automaticity of reading words. For instance, Rosinski, Golinkoff and Kukish (1975) found picture naming was largely disrupted by the presence of incongruent word stimuli, whereas the naming of words was relatively unaffected by incongruent pictorial stimuli. Because of the relatively little interference pictures have on word naming, the semantic relatedness effect of pictures on word naming has not been extensively uninvestigated. However, the automatic semantic processing theory of pictures noted earlier suggests that the semantic relatedness of pictures may have an effect on how words are processed, although the task used might be a critical factor.

To further complicate the potential semantic effects of pictures on word memory, research has also suggested the possibility of semantic facilitation under some conditions. Using the picture-word interference paradigm, Costa et al. (2005) noted that distractor words that fell into the same semantic category as a picture had in fact produced semantic interference (e.g. a target picture of a car and a distractor word truck) as suggested by previous studies. However, they also noted that if a distractor word was semantically related but from a different category, (e.g. the target picture car and the distractor word bumper) semantic facilitation rather than interference was observed. In a similar study, researchers Mahon et al. (2007) also noted semantic facilitation effects using the picture-word interference task. Compared to unrelated distractor words, their first set of experiments demonstrated that target pictures (e.g., bed) were

named faster in the presence of a semantically related distractor verb (e.g., sleep) than unrelated distractor verbs (e.g., shoot). Additionally, it was noted that target naming of a picture (e.g., horse) was faster for within-category semantic distractors that were close in relationship to the target (e.g., zebra) than for within-category semantic distractors that were farther in relationship to the target (e.g., whale). That is, the closer the semantic relationship to the target, the greater the facilitation effects and the faster the target naming. Studies such as those just discussed suggest that semantic facilitation rather than intrusion effects in target picture naming may occur in the picture-word interference task in the presence of semantically related distractors. Given the task variations, the question then becomes whether semantically related pictures will have similar effects on word memory. The potential for both intrusion and facilitative effects in the picture-naming task have been demonstrated and suggests that the effects of semantically related pictures on word memory could facilitate or inhibit depending on the specific conditions.

The literature reviewed has illustrated a great deal support for pictorial facilitation effects as well as the pictorial superiority effect. Many views and theories have been proposed concerning the superior nature of picture encoding over word encoding and research investigating how pictures reinforce text and word processing has largely supported these views. Although the literature provides some indication of picture intrusions on word categorization, the overall intrusion of pictures on words is still a relatively unexplored area of research. Beyond the scope of the potential negative effects of pictures when teaching children sight vocabulary, research concerning picture intrusion on subsequent word memory and learning is largely absent. The potential effects of pictures at the time of word encoding on subsequent word memory has, to the author's knowledge, not been investigated. Although a great deal of information has been

acquired regarding pictorial influence on word processing, there remains much to be learned regarding the nature of the relationship between picture and word processing.

Purpose

The purpose of the current study is to explore further the processes involved in memory for words in the presence of accompanying pictures. Due to the superior encoding nature of pictures, it was expected that the presence of pictures when encoding words will provide either facilitation or interference depending its relationship to the target word. Most research regarding adults suggests that corresponding pictures facilitate word processing (e.g., Stenberg et al., 1995; Israel & Schacter, 1997; Waddill et al., 1988). Thus, for the first experiment, it was predicted that this facilitation effect will carry over to the memory of to-be-remembered words in a list presented with matching pictures. However, the superior encoding nature of pictures was expected to interfere with the encoding and memory of words in a condition in which the picture is incongruent and unrelated to a word. Though research showing the inhibitory effects of pictures on words is scarce, the existing research suggests that inhibitory effects may take place in certain instances (e.g., categorization; Smith & Magee, 1980, Arieh & Algom, 2002; Lupker & Katz, 1982). As pictures are more easily encoded and remembered than words, the presence of a distractor picture may inhibit the effective encoding of a word into memory. Lastly, according to the dual code hypothesis, pictures are encoded both visually and non-visually (Paivio, 1971; Pellegrino et al., 1975; Snodgrass & McClure 1975; Nelson, et al, 1976; Mintzer & Snodgrass, 1999). Due to the additional verbal code pictures receive with the visual code, if the dual code hypothesis is tenable, pictures that are presented in the recognition condition in their alternate word form, may be mistakenly remembered as being presented in word form during the study portion.

Semantic relatedness research using the picture-word interference task suggests that the semantic relatedness of a distractor to a target stimulus may affect the encoding process. The semantic processing theory of pictures, as demonstrated in studies such as Lupker and Katz (1982), as well as the semantic research using the picture-word interference task illustrate the intrusion effects that semantically related stimuli have on a target stimulus. Alternatively, other research using the picture-word interference task also suggests the possibility of semantic facilitation effects (Mahon et al., 2007; Costa et al., 2005). The majority of this research has examined the influence of words on pictures. Thus, the current study will extend this research through an examination of pictures on the processing of words. It was hypothesized that semantically related pictures will influence the memory of target words, although it is possible that these effects may be intrusive or facilitative. In summary, the present study served four purposes. First was to establish whether matching pictures presented with words facilitates the later memory of the words. Second, was to investigate whether incongruent/unrelated pictorial stimuli will inhibit the memory of the target words. Next was to investigate whether semantically related pictures presented in Experiment 2 will have an inhibitory or facilitative effect on word memory. Fourth, although a less central purpose, was to establish whether the incongruent pictures from Experiment 1 are dually encoded and later falsely recognized in their word form during the recognition test.

CHAPTER 2

EXPERIMENT 1

Method

Participants. Participants were 48 (14 males, 34 females) Introductory Psychology students at Georgia Southern University who participated as a requirement for course credit. There were originally 51 participants, however, 2 participants were not included in the analysis due to experimenter error, and 1 participant was not included due to equipment error.

Design and procedure. Each participant was presented with one of three possible lists of 120 to-be-remembered stimuli, consisting of 40 items per condition. Three different lists were employed so that across participants all stimulus words appeared in each of the three conditions. Participants were randomly assigned to one of the three lists. The stimuli consisted of words in lower case letters with a picture presented above the word. Participants were instructed to devote their attention to the words presented in the stimuli pairs and not the pictures accompanying the words. The pictorial stimuli consisted of familiar items adapted by Rossion and Pourtois (2004) from Snodgrass and Vanderwart's (1980) black and white pictorial database. Rossion and Pourtois converted the pictures to color and collected normative data on the objects and their labels. Critical stimuli were selected at random, with the restriction that items with two word labels (e.g., baby carriage) were not included. Fillers in the recognition task were also selected from this database.

Three word-picture conditions were presented to participants. The first condition consisted of 40 words with matching pictures, the second condition consisted of 40 words presented with a neutral picture (i.e.: a row of four X's), and the third condition words were 40 words presented with incongruent pictures (see appendix A for examples). In the incongruent

condition, the forty pictures were paired words unrelated to the picture. These 40 incongruent picture-word pairs were used across all lists.

Stimuli were presented to participants on a computer screen at two-second intervals. After the presentation of the 120 stimuli, participants were given a recognition task in which they were asked to indicate whether they had seen a given word in the study portion. The recognition task consisted of 80 filler words that the subject had never seen, the 120 critical words previously presented, and the 40 alternate word form of the incongruent pictures that were presented in the study task. That is, if a picture of an airplane had been presented in the study task with an incongruent word, the word airplane was included in the recognition test. Participant results were based on mean accuracy rates for each participant in the recognition task. Participants responded "yes" or "no" using the keys on a keyboard "a" or "s" for left handed, and the keys "k" or "l" for right-handed participants.

Results and Discussion

A one-way repeated-measures ANOVA was used to analyze differences among mean accuracy rates. The picture manipulation had an effect on the recognition memory of the words, $F(2, 94) = 19.03$, $p < .05$. Pairwise comparisons were analyzed using a Bonferroni adjustment. Words presented with matching pictures ($M = .62$, $SEM = .02$) were better recognized than words presented with incongruent ($M = .54$, $SEM = .02$) or neutral pictures ($M = .53$, $SEM = .02$). There were no other differences among the conditions. Finally, the hypothesis regarding the dual-code theory in which it was hypothesized that incongruent pictures that were presented in their alternate form during the recognition task would have a high false positive rate was not supported by the results. For the incongruent pictures that were presented as words, the false positive rate was (26%), which although somewhat higher then false positives for fillers (14%),

was substantially lower (in terms of participants believing that they had previously seen the word) than either the neutral, congruent or incongruent conditions. That the incongruent pictures presented in word form revealed relatively low false positive rates, in tandem with the facilitative effect of matching pictures would seem to provide support for frameworks such as the sensory-semantic model (Nelson et al, 1975) and common code theory (Stenberg et al., 1995) rather than a dual-code theory of picture superiority (Paivio, 1969,1971).

The result regarding the matching picture condition is consistent with the well-documented facilitative nature of pictures on memory. Participants recognized words that were presented in the matching word-picture condition more accurately than those presented in any of the other conditions. In contrast, there was no significant difference between the recognition of words in the incongruent or neutral conditions. Although pictures are presumed to be more easily encoded and stored in memory as demonstrated throughout the literature, the presence of the irrelevant pictures did not interfere with the encoding of the words. This finding suggests that although pictures may be processed more efficiently or easily in some cases, they do not take primacy over words in an automatic fashion in a task in which verbal memory is emphasized. The extent to which this finding extends to picture word relationships beyond simply completely incongruent or exact matches was explored in Experiment 2.

CHAPTER 3

EXPERIMENT 2

Method

Participants. Participants were 50 (14 males, 36 females) Introductory Psychology students at Georgia Southern University who participated as a requirement for course credit. There were 51 original participants, however, one participant was not included due to equipment error.

Design and procedure. As in experiment 1, each participant was presented with one of three lists consisting of 120 to-be-remembered stimuli, 40 items per condition. The pictorial stimuli were again selected from Rossion and Pourtois (2004). The three conditions for experiment 2 were as follows: semantically related, unrelated/incongruent and neutral (i.e., a row of four X's) picture-word pairs (see appendix B for examples). The stimuli for the semantically related condition consisted of a picture and a semantically related word. The associative norms were taken from the Edinburgh Associative Thesaurus (Kiss, Armstrong, Milroy, & Piper, 1973; http://www.eat.rl.ac.uk) and The University of South Florida word association, rhyme, and word fragment norms at http://www.usf.edu/FreeAssociation/. The incongruent condition remained as in Experiment 1. That is 40 words paired with 40 unrelated pictures. As in Experiment 1, these were constant across lists. Participants were presented the picture-word and then engaged in a subsequent recognition task consisting of the 40 semantically related, 40 neutral and 40 incongruent words as well as 120 filler words that did not appear in the picture-word phase of the study. As in Experiment 1, results were based on the accuracy of the recognition task. Participants responded by pressing appropriate buttons on the computer keyboard.

Results and Discussion

Two missing data points were not included in the analysis due to lack of participant response. Results were analyzed using a one-way repeated-measures ANOVA. The picture condition had an effect on the recognition memory of the words, $F(2, 98) = 6.90$ $p < .05$. Pairwise comparisons were analyzed using a Bonferroni adjustment. Words presented with semantically related pictures ($M = .53$, $SEM = .02$) were better recognized than words presented with incongruent ($M = .49$, $SEM = .02$) or neutral pictures ($M = .47$, $SEM = .02$). There were no other differences among the conditions.

Results indicate that the facilitative nature of pictures is not restricted to exact matches; pictures that are semantically related to a word also facilitated word memory. The lack of significant difference between the incongruent/unmatching and neutral conditions replicated the findings of Experiment 1. Implications of these findings are discussed.

CHAPTER 4

GENERAL DISCUSSION

The purpose of this study was to further explore the effects of pictorial stimuli on word recognition memory. As evidenced by the results of both experiments, even in the presence of conflicting stimuli, it appears that participants were able to benefit from relevant pictorial information while ignoring disadvantageous or irrelevant information. Congruent with research that has shown pictures to be more easily and efficiently encoded and better remembered (Paivio, 1969, 1971; Snodgrass &McClure, 1975; Nelson et al., 1976; Stenberg et al., 1995; Stenberg, 2006) these results indicate that participants were able to advantageously use pictures in matching and semantically related conditions to facilitate memory. However, this suggests that picture superiority does not translate into primacy such that memory is automatically influenced by pictorial information when that information contradicts the verbal information. The ability to make use of the pictures in a discriminating fashion, suggests that participants may have implemented a primarily verbal based memory, selectively supporting this memory when possible with the visual information.

One possible explanation for the lack of interference by incongruent pictorial information may be explained in terms of the ability of adults to be able to selectively divert and withhold attention relative to the stimuli. Research has suggested that underachieving children are more distracted and exhibit more detrimental effects than overachiever children by distracting stimuli (Baker & Madell, 1965 and Silverman, Davids, & Andrews, 1963 as cited in Samuels, 1967). Given that participants were instructed in the present study to focus on lexical memory, and as adults have fully developed reading skills, it is possible that the adult college population examined in the present study were reasonably adept at diverting attention from irrelevant

stimuli. The findings suggest that, if task conditions emphasize verbal processing, this is not superceded even by the rich information contained in distractor pictures.

That this might be a function to some degree of selective attention, is illustrated by the finding that participants were able to use the matching pictures to their benefit even in the context of a list that contained mismatched and neutral stimuli. This result in combination with the finding that the incongruent pictures were not detrimental to memory performance, even when presented in their alternate word forms, suggests that participants *strategically* utilized pictorial information rather than ignoring the pictorial information all together. It could be argued, however, that pictorial information may not be beneficial when it is semantically related, but distinct as it would activate a related, but different concept than the target word. The extent to which semantically related pictorial information positively or negatively affects verbal memory was examined in Experiment 2. The finding that semantically related pictures were also beneficial to the memory of words, while again there appeared to be no evidence of interference by unrelated pictures, supports the above mentioned notion that participants utilized pictorial information strategically to support verbal memory.

One means by which participants may be able to selectively extract beneficial information from pictures is if pictures are analyzed primarily at the semantic level (see also Stenberg et al., 1995). The notion that pictures emphasize semantic processing and are analyzed primarily at a conceptual level is substantiated by research concerning the picture-word interference task finding that words interfere with the labeling of pictures, however the naming of words is unaffected by the presence of incongruent pictures (Smith & Magee, 1980; Rosinski et al., 1975). Additionally, research also indicates that pictures interfere with the categorization of words, a semantically based task, whereas picture categorization is relatively immune to the

presence of irrelevant words (Smith & Magee; Lupker & Katz, 1982; Arieh & Algom, 2002). Thus, taken as a whole, the research lends credence to the assumption that pictures are processed more rapidly in terms of semantic information but more slowly activate verbal (e.g., orthographic-phonological) information. The emphasis of words however is on the orthographic-phonological aspects with access to semantic information less rapidly available (Smith & Magee).

These results can also be accounted for within a spreading activation model such as network models of semantic memory (Collins & Quillian, 1969; Collins & Loftus, 1975). If pictures do lead to superior semantic processing (Stenberg et al., 1995), congruent pictures might activate nodes representing word's meanings to a greater extent, leading to better memory. In the case of semantically related, but verbally distinct pictures, it could be argued that even though the semantically related pictures were not an exact match to the target words, they may have activated analogous nodes within the semantic network of the target, which in turn supported formation of the verbal level.

If the semantic level activation does indeed support verbal level information, it may be useful to also consider an explanation within interactive distributed models of word processing in order to better elucidate the relationship between word and picture processing (e.g., Seidenberg & McClelland, 1989; Seidenberg, 2005). A distributed model is comprised of separate neuron-like units representing the different levels of a word: orthographic (spelling), phonological (pronunciation) and the semantic (meaning). The processing of words involves the activation of units connected by weights in which the patterns of activation correspond to the different levels of the word (e.g., the orthography). A main contention of distributed models is the interactive nature of the unit representations. All of the computational levels of a word are fully

interconnected and act in parallel with one another (see Seidenberg and Seidenberg & McClelland for further explanation of the models). In a model in which input information such as a word activates orthographic, phonological and semantic units of processing, memory would presumably be a function of the orthographic and phonological as well as semantic information associated with an input word. Pictorial information may be utilized as a form of contextual information such that participants are able to extract the semantic information from the picture while disregarding other information that might be activated (the word form of the picture). This enhanced semantic information (from the picture) would then support the verbal and visual levels of processing via interactive support from the semantic level (e.g., Pexman and Lupker, 1999; Seidenberg & McClelland, 1989). The notion that the current findings are primarily a semantic-level effect of pictures is supported by the finding from Experiment 2 in which distinct pictures that are semantically related to the target word facilitated memory. Also, that pictures presented in word form did not lead to excessively high false positive rates in the picture-word condition suggests that semantic information was used to direct attention to relevant pictures (as participants did not mistakenly recognize the word-level forms of the pictures). Thus, picture-word processing in this context may be a function of selective attention based on semantic attributes of contextual pictorial information.

Finally, the results provide some insight into theories of picture superiority, at least in regard to how pictures are processed. In terms of the *dual-code hypothesis*, results did not support the notion that processing of pictures involves an automatic verbal component. As noted, had pictures been automatically stored dually (visually as well as verbally) as projected by the *dual-code hypothesis* (Paivio, 1969, 1971), one would expect a high false positive rate during the recognition task in which the pictures were subsequently presented as their verbal label.

Although the scope of this study was not to establish which of the many theories of picture superiority is most accurate, results do most likely exclude a dual-coding view. Results are instead supportive of theories of semantic based pictorial advantage (Stenberg et al., 1995; Stenberg, 2006). That is, the basis of picture superiority has been argued to be superiority primarily in conceptual processing. Stenberg (2006) argues the superior conceptual (semantic) processing of pictures is a stronger contribution to the effect than perceptual and sensory properties as emphasized in other theories (Nelson et al., 1976; Mintzer & Snodgrass, 1999). Arguments for a semantic based advantage for pictorial information assumes pictures more efficiently access semantic representations than words. Deeper processing at the semantic level presumably leads to better retention, and thus the picture superiority effect emerges. A similar argument has been made here in that picture effects were facilitative, but not intrusive as they were processed primarily in terms of meaning without activating or emphasizing an accompanying verbal code. It should be noted, however, that the results do not rule out the possibility that dual-coding may arise in some contexts or tasks in which a dual code might be beneficial. However, it would appear this is not necessarily automatic, but rather supports the assertion made by Nelson and Reed (1976) that whether or not a verbal label is applied to a picture is under control of the individual. That is, the application of a verbal label to a picture may be a function of the perceived utility for the task. If the verbal label of the picture can directly relate to the information at hand, the labeling of the picture will most likely be implemented. However, if the utilization of the verbal label is not beneficial to the participants (as exampled in the non-matching conditions), a label will not be applied.

Although the pictures did not interfere with word recognition in this particular study, further research should explore picture-word effects within other contexts. As discussed

previously, much of the research regarding intrusion effects of pictures on words has been completed within the parameters of children learning sight vocabulary (Singh & Solman, 1990; Solman & Singh 1992; Conley et al., 2004). Although matching pictures have been shown to be beneficial to adults, as was also supported by the results of this study, the use of corresponding pictorial supplements may not be beneficial when provided to children (Singh & Solman; Solman & Singh; Conley et al.; Samuels, 1967). This differential benefit of using pictorial supplements between adults and children may be because adults possess better-developed word processing abilities relative to children. Children may also not have developed the attentional mechanisms sufficient to selectively extract relevant information from some pictures while disregarding others. Thus, pictures shown to children in conjunction with words are not reinforcing the word-level representation but rather distracting from it (Singh & Solman; Solman & Singh; Samuels). In adults, the written and verbal associations of the word are established and the processing of words is largely automatic (Guttentag & Haith, 1979). Consequently, pictures reinforce the target word due to their rich sensory and semantic qualities, but only in the case in which the pictorial stimuli are beneficial.

However, pictures may not necessarily be beneficial to adults in all conditions. Similar intrusive effects such as those seen in children learning their native language may be seen in children and adults learning the vocabulary of a second language. As second languages are often taught using the same method of pairing vocabulary with pictures and one is establishing new and sometimes unfamiliar orthographic-phonologic connections, intrusion effects of pictures may be very likely.

In regard to limitations of the current study, participants were directly instructed to attend to the words and told they were to be subsequently tested on the words. A different pattern may

have been observed if instructions were changed such as to emphasize the importance of pictures or to present a surprise memory task rather than inform participants that words would be the focus of testing. Additionally, in regard to semantic relatedness, different types of relationships were not examined such as differences between associative relationships verses semantic relationships (e.g., see Locker, Simpson, & Yates, 2003). Lastly, task conditions and contextual variations (e.g., contrast changes between the print and background, size of picture and size of font) may play a large role in determining the potential intrusion effects of pictures on word processing (Arieh & Algom, 2002).

Generally, the results of this study are indicative of an ability of participants to focus attention primarily on word-level information (and thus an orthographic-phonologic primacy) and strategically utilize pictures only when it is beneficial (i.e., when the aim is verbal memory performance). Although pictures have highly superior encoding properties (Nelson et al., 1976; Mintzer & Snodgrass, 1999; Nelson & Reed, 1976; Stenberg et al., 1995; Stenberg, 2006), the advantages of pictures do not detract from the encoding of words in conditions in which the pictures are incongruent and thus conflict with the target. Pictures, were however beneficial in matching and related conditions. I have argued in the present study that this benefit may be primarily semantic in nature. The present results do lend support for the already wide use of pictorial stimuli to reinforce and facilitate learning and comprehension of words and text in adult populations. However, potential intrusion effects of pictures on word processing requires further investigation in different experimental contexts.

REFERENCES

Arieh, Y., & Algom, D. (2002). Processing picture--word stimuli: The contingent nature of picture and of word superiority. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*, 221-232.

Carney, R. N., & Levin, J. R. (2002). Pictorial illustrations still improve students' learning from text. *Educational Psychology Review, 14*, 5-26.

Caramazza, A., & Costa, A. (2000). The semantic interference effect in the picture-word interference paradigm: does response set matter? *Cognition*, *75*, B51-B64.

Collins, A. M., & Loftus, E. F. (1975). A Spreading-Activation Theory of Semantic Processing. *Psychological Review*, *82*, 407-428.

Collins, A. M., & Quillian, M. R. (1969). Retrieval Time from Semantic Memory. *Journal of Verbal Learning and Verbal Behavior*, *8*, 240-247.

Conley, C. M., Derby, K. M., Roberts-Gwinn, M., Weber, K. P., & McLaughlin, T. F. (2004). An analysis of initial acquisition and maintenance of sight words following picture matching and copy, cover, and compare teaching methods. *Journal of Applied Behavior Analysis, 37*, 339-350.

Costa, A., Alario, F.-X., & Caramazza, A. (2005). On the categorical nature of the semantic interference effect in the picture-word interference paradigm. *Psychonomic Bulletin & Review*, *12*, 125-131.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing. A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*, 671-684.

Damian, M. L., and Bowers, J. S. (2003). Locus of semantic interference in picture-word interference tasks. *Psychonomic Bulletin & Review,* 10, 111-117.

Glenberg, A. M., & Langston, W. E. (1992). Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory and Language, 31*, 129-151.

Goodman, K. S. (1965). A linguistic study of cues and miscues in reading. *Elementary English, 42*, 639-643.

Guttentag, R. E., & Haith, M. M. (1979). A developmental study of automatic word processing in a picture classification task. *Child Development, 50*, 894-896.

Israel, L., & Schacter, D. L. (1997). Pictorial encoding reduces false recognition of semantic associates. *Psychonomic Bulletin & Review, 4*, 577-581.

Jenkins, J. R., Neale, D. C., & Deno, S. L. (1967). Differential memory For Picture and word stimuli. *Journal of Educational Psychology, 58*, 303-307.

Kiss, G. R., Armstrong, C., Milroy, R., & Piper, J. (1973) An associative thesaurus of English and its computer analysis. In Aitken, A.J., Bailey, R.W. and Hamilton-Smith, N. (Eds.), The Computer and Literary Studies. Edinburgh: University Press.

Kiss, G.R., Armstrong, G., & Milroy, R., The Associative Thesaurus of English. Edinburgh (1972).

Levin, J. R. (1986). Four cognitive principles of learning-strategy instruction. *Educational Psychologist, 21*, 3-17.

Locker, L., Simpson, G. B., & Yates, M. (2003). Semantic Neighborhood Effects on the Recognition of Ambiguous Words. *Memory & Cognition*, *31*, 505-515

Lupker, S. J., & Katz, A. N. (1982). Can automatic picture processing influence word judgments? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8*, 418-434.

Mahon, B.Z., Costa, A., Peterson, R., Vargas, K.A., & Caramazza, A. (2007). Lexical selection

is not by competition: A reinterpretation of semantic interference and facilitation effects in the picture-word interference paradigm. *Journal of Experimental Psychology*, *33*, 503-535.

Mintzer, M. Z., & Snodgrass, J. G. (1999). The picture superiority effect: Support for the distinctiveness model. *American Journal of Psychology, 112*, 113-146.

Nelson, D. L., & Reed, V. S. (1976). On the nature of pictorial encoding: A levels-of-processing analysis. *Journal of Experimental Psychology: Human Learning and Memory*, *2*, 49-57.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (1998). The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu/FreeAssociation/.

Nelson, D. L., Reed, V. S., & Walling, J. R. (1976). Pictorial superiority effect. *Journal of Experimental Psychology: Human Learning and Memory*, *2*, 523-528.

Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological Review, 76*, 241-263.

Paivio, A. (1971). *Imagery and verbal processes* . Oxford, England: Holt, Rinehart & Winston xi, pp. 596.

Pellegrino, J. W., Siegel, A. W., & Dhawan, M. (1976). Short-term retention of pictures and words as a function of type of distraction and length of delay interval. *Memory & Cognition, 4*, 11-15.

Pexman, P. M., & Lupker, S. J. (1999). Ambiguity and Visual Word Recognition: Can Feedback Explain Both Homophone and Polysemy Effects? *Canadian Journal of Experimental Psychology*, *53*, 323-334.

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and*

Cognition, *21*, 803-814.

Rosinski, R. R. (1977). Picture-word interference is semantically based. *Child Development, 48*, 643-647.

Rosinski, R. R., Golinkoff, R. M., & Kukish, K. S (1975). Automatic Semantic Processing in a Picture-Word Interference Task. *Child Development*, *46*, 247-253.

Rossion, B., & Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object set: The role of surface detail in basic-level object recognition. *Perception*, *33*, 217-236.

Sadoski, M. (2005). A dual coding view of vocabulary learning. *Reading & Writing Quarterly: Overcoming Learning Difficulties, 21*, 221-238.

Samuels, S. J. (1967). Attentional process in reading: The effect of pictures on the acquisition of reading responses. *Journal of Educational Psychology, 58*, 337-342.

Seidenberg, M. S., (2005). Connectionist Models of Word Reading. *Current Directions in Psychological Science*, *14*, 238-242.

Seidenberg, M. S., & McClelland, J. L., (1989). A Distributed, Developmental Model of Word Recognition and Naming. *Psychological Review*. 96, 523-568.

Singer, H., Samuels, S. J., & Spiroff, J. (1974). The effect of pictures and contextual conditions on learning responses to printed words. *Reading Research Quarterly, 9*, 555-567.

Singh, N. N., & Solman, R. T. (1990). A stimulus control analysis of the picture-word problem in children who are mentally retarded: The blocking effect. *Journal of Applied Behavior Analysis, 23*, 525-532.

Smith, M. C., & Magee, L. E. (1980). Tracing the time course of picture-word processing. *Journal of Experimental Psychology: General, 109*, 373-392.

Snodgrass, J. G., & McClure, P. (1975). Storage and retrieval properties of dual codes for

pictures and words in recognition memory. *Journal of Experimental Psychology: Human Learning and Memory, 1*, 521-529.

Solman, R. T., Singh, N. N., & Kehoe, E. J. (1992). Pictures block the learning of sightwords. *Educational Psychology, 12*, 143-153.

Stenberg, G. (2006). Conceptual and perceptual factors in the picture superiority effect. *European Journal of Cognitive Psychology, 18*, 813-847.

Stenberg, G., Radeborg, K., & Hedman, L. R. (1995). The picture superiority effect in a cross-modality recognition task. *Memory & Cognition, 23*, 425-441.

Vitkovitch, M., & Tyrrell, L. (1999). The effects of distractor words on naming pictures at the subordinate level. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 52*, 905-926.

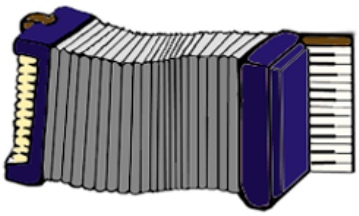
Waddill, P. J., & McDaniel, M. A. (1992). Pictorial enhancement of text memory: Limitations imposed by picture type and comprehension skill. *Memory & Cognition, 20*, 472-482.

Waddill, P. J., McDaniel, M. A., & Einstein, G. O. (1988). Illustrations as adjuncts to prose: A text-appropriate processing approach. *Journal of Educational Psychology, 80*, 457-464.

APPENDIX A

SAMPLE STIMULI EXPERIMENT 1

Matching Stimuli



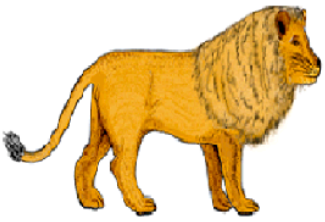
accordion

Neutral Stimuli

xxxx

hammer

Incongruent/unmatching Stimuli

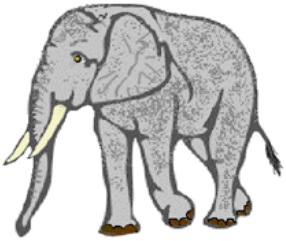


hat

APPENDIX B

SAMPLE STIMULI EXPERIMENT 2

Semantically Related Stimuli



giraffe

Neutral Stimuli

xxxx

foot

Incongruent/unmatching Stimuli

truck