SPELLING SKILL AND THE EFFECTIVENESS OF RHYME AND SEMANTIC HINTS TO ANAGRAM SOLUTIONS

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Spelling Skill and the Effectiveness of Rhyme and Semantic Hints to Anagram Solutions

by

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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Masters of Science

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Memorial University of Newfoundland

May 1998

St. John's Newfoundland

Running Head: Anagram Solutions

Abstract

The present experiment was designed to investigate anagram solution as a function of spelling ability and type of hint. Forty-eight university undergraduates, identified as good or poor spellers, were presented with anagrams until 15 were missed. Subjects then memorized a list of words for immediate recall in serial order. Words in the memory list were related phonetically and orthographically, semantically, or were unrelated to the previously missed anagrams. Following the serial recall task, subjects were presented again with those anagrams previously missed. An interaction was predicted to occur between spelling ability and type of hint when solving anagrams. Rhyme hints were expected to facilitate anagram solving in good spellers, but not in poor spellers. The only significant finding was that good spellers solved more anagrams than did poor spellers. Both types of hints (rhyme and semantic) were ineffective and no interaction was found between spelling ability and type of hint. A possibility of serial order difficulty is discussed.

Acknowledgements

First, I would like to thank Dr. Cathy Penney, Dr. Rita Anderson, and Dr. Mary Courage for their endless patience. Through their encouragement and support over the past few years, I was able to obtain this treasured goal. Financially, I would like to acknowledge support from the Department of Psychology.

I would also like to thank Tee Yong Teoh for his time and energy in helping create the computer program for this project. As well, I would like to thank Brenda Noftle, Kim French, Bernice St Croix, and Maureen Howard for being there to find answers to all of my questions. For all their time, patience, energy, coffee, and shoulders, I would like to extend my sincerest appreciation and love to Sean and Carolyn Todd, Elizabeth Votta, Dave Rosen, and Rod Taylor.

Finally, this thesis is dedicated to the one person who made this possible, my father. His belief in my success and his endless devotion to my future will never go unnoticed.

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Anagrams are jumbled letters that can be rearranged to form a real word (Fink & Weisberg, 1981; Foley, Foley, Wilder & Rusch, 1989). The study of how anagrams are solved should provide some insight into the cognitive processes that play a role in problem solving and spelling ability. This includes how letters are arranged. Without knowledge of spelling patterns, letter rearrangement will be difficult. Letter rearrangement is not merely a random process. Instead, as the following literature review will demonstrate, anagrams are solved by selecting a frequent letter pattern, rearranging the remaining letters around this pattern, and using this new arrangement as a retrieval cue to generate words. The retrieved words are then examined to determine whether there is a match with the letters in the anagram. If the retrieved word is not the solution to the anagram, the process is repeated until a solution is found.

Improving the probability of word retrieval should increase the probability of correctly solving the anagram. When hints to a solution are provided, information related to the hints is activated. The activated information is then available for retrieval. Subsequently, direct hints to a solution improve the chances of correctly solving the anagram. Two types of hints, or cues, for solving anagrams exist. The first is within the anagram. The anagram provides cues to its solution through letter order and pronunciation. The visual, or orthographic, cues help activate possible anagram solutions. Words with letter patterns similar to those of the anagram will be activated and made available for retrieval. The closer the letter order of the anagram is to the solution word, the easier it will be for the problem solver to retrieve the correct solution. Similarly, pronouncing the anagram provides auditory cues to the anagram solution. When the letter

units in the anagram are pronounced the same as the letter units in the solution. words with similar auditory information are activated. Thus. the solution to the anagram is available for retrieval.

The second type of cue is from outside the item as revealed by priming studies. Priming refers to the use of a cue to activate words in memory in advance of their presentation (Reber. 1985). A concept is presented to influence a later task. Priming can activate the concept itself as well as related concepts. The stimulus that is influenced by the prime is known as the target. The lexical decision task has been used to test the effect of priming (Ashcraft. 1994; Hirshman & Durant. 1992; Meyer & Schvaneveldt. 1971). This task involves deciding if a letter string is a word. Semantic priming, as found in a lexical decision task. can occur at a subconscious level of awareness (Ashcraft. 1994). Therefore. the use of primes in solving anagrams should activate associated words. Cues such as related rhyme and semantic words can be used to influence an anagram solution. Priming prior to presentation of an anagram will increase the probability of activating related words and facilitate retrieval of the correct anagram solutions (Dominowski & Ekstrand. 1967; Schuberth. Spoehr, & Haertel. 1979; White. 1988). Current studies report that semantic hints are helpful and that presenting various types of letter cues is beneficial to anagram solutions.

Poor spellers appear to have difficulty correctly arranging letters (Fischer. Shankweiler, & Liberman, 1985). Therefore. spelling ability is assumed to play a major factor in anagram solving. Although past research on the ability of good and poor spellers

to solve anagrams does not exist, spelling ability is intuitively relevant to the process of finding anagram solutions. Anagrams should be very difficult for the poor speller to solve. The critical question, however, is whether the type of cue provided, rhyme or semantic, will affect subjects differently. To answer this question, care must be taken to eliminate cues found in the anagrams themselves, including controlling letter order and pronunciation. The present study investigated the effect of specific types of cues (semantic and rhyme) on the ability of good and poor spellers to solve anagrams.

Variables Affecting Anagram Solution

Anything that decreases the number of possible letter rearrangements should facilitate the process of solving the anagram. Many variables have been reported to improve anagram solving ability including word length (Kaplan & Carvellas, 1968), the presence of repeated letters (Murray & Mastronardi, 1975), letter order (Dominowski, 1968; Foley, Foley, Wilder, & Rusch, 1989; Mendelsohn, 1976; Murray & Mastronardi, 1975), and pronunciation of the anagram (Dominowski, 1969; Fink & Weisberg, 1981). An important distinction to bear in mind is that the anagram itself provides cues to its solution through these variables. Letter cues and word length provides visual (orthographic) cues whereas pronunciation provides auditory (phonological) cues.

Letter order and letter cues. The closer the letter order of the anagram is to the letter order of the solution, the easier the anagram will be to solve (Foley, Foley, Wilder, & Rusch, 1989; Mendelsohn, 1976; Murray & Mastronardi, 1975). If the letter order is drastically different from the solution word or has letters that cue inappropriate words,

incorrect possible solutions will be activated. Mendelsohn (1976) suggested that anagram solving is related to retrieval processes from long-term memory. He proposed that anagram problem solvers select common letter sequences and then arrange the remaining letters around the cluster. When an anagram containing a common letter pattern is viewed, words with that pattern are activated and retrieved. The letter patterns act as retrieval cues for possible solution words. For example, the bigram "GR" is commonly found in the English language. When a problem solver with a good knowledge of spelling patterns is presented with the anagram ***AEGRT***, the bigram is readily selected and possible words are activated and retrieved, such as 'grate' and 'greet'. Other words beginning with "GR" and having the same letters in common with the anagram are also activated and retrieved until the solution word GREAT is found. If the letters in the cluster are already placed together in the anagram, e.g., ***EATGR***, the anagram will be easier to solve than when the frequent letter clusters are separated.

In Mendelsohn's (1976) experiment, subjects provided a solution to five-letter anagram. The letter strings were created so that one-third of the anagrams could be solved by rearranging the letters in one move (e.g., ***CHATR*** requires one rearrangement to form the solution CHART), one-third of the anagrams could be solved by rearranging the letters in two moves (e.g., ***HCATR***), and one-third of the anagrams could be solved by rearranging the letters in three moves (e.g., ***TACRH***). Anagrams with a one-letter move were easier to solve than anagrams requiring more rearrangement. Similarly, anagrams requiring two-letter moves were easier to solve than anagrams requiring three-letter

moves. The difficulty of solving the problem increased as the number of moves required for solution increased due to the likelihood of the anagram not looking like the solution word. Anagrams that contained letter sequences corresponding to those sequences in the solution word were solved more easily. It appears that subjects used the anagram itself as a retrieval cue. For example, ***CHATR*** acts as a retrieval cue by providing orthographic (visual) information that is directly linked to the solution CHART.

Dominowski (1968) investigated the effects of providing subjects with information about the solutions to five-letter anagrams. Subjects were presented with an anagram alone or an anagram plus a hint. Four different types of hints were offered: the correct position of one letter in the solution word, the order but not positions of two letters, the correct order and positions of two letters, or the order but not positions of three letters. Subjects presented with the trigram clue (order of three letters) solved more anagrams than did any of the other subjects. Subjects who were presented with the bigram clue (order of two letters) and its position solved more anagrams than subjects presented with the bigram clue alone. Subjects presented with the correct position of one letter solved fewer anagrams than those in the other conditions did where a clue was presented, but the fewest number of anagrams was solved when no hint was provided.

One explanation for the results is that the number of permutations of the letters decreased with the addition of hints. As the number of permutations decreased, the number of correct anagrams solved increased. The difference in the number of correctly solved anagrams between the conditions of a trigram cue and the bigram-plus position cue

was not large, but a large difference did occur between those cues and the bigram cue alone. In the trigram condition, once the three-letter cluster was known, only six-possible arrangements of the letters were left for the solution. There were 24 possible arrangements of the letters in the bigram and the monogram (correct position of one letter) conditions. One hundred twenty possible arrangements had to be checked when no hints were provided.

Visual presentation of an anagram can influence finding the solution. The more similar the letter string is to the solution, the easier the anagram will be to solve due to the visual cues. Cues within the letter string include letter order and letter grouping of bigrams and trigrams. The cues are expected to increase the probability of retrieval by increasing access to possible solutions. Other factors within the letter string that could affect the ease of solving the anagram are word length and repeated letters.

Word length and repeated letters. The longer the anagram, the more letters there are in the anagram, and therefore, the more possible arrangements of the letters. Consequently, one expects solution time to increase with an increase in anagram length. A four-letter anagram without repeated letters, for instance, will have 24 possible letter arrangements; at least one of which will be a solution. Similarly, a five-letter anagram with no repeated letters will have 120 possible arrangements of the letters and a six-letter anagram with no repeated letters will have 720 possible arrangements of the letters. When letters are repeated, the number of arrangements is reduced, so that a four-letter anagram with one repeated letter will have 12 possible arrangements of the letters, rather than 24.

A six-letter anagram with one repeated letter will have 360 possible arrangements of the letters, instead of 720. Longer words have a greater probability of including repeated letters that decrease the number of possible arrangements. Consequently, the time to solve anagrams does not necessarily continue to increase as the number of letters in an anagram increases.

Kaplan and Carvellas (1968) investigated the effect of word length on anagram solution time. Subjects were presented with anagrams varying in length from three to ten letters and were instructed to state the solution aloud. The time to solution increased with the addition of letters up to five letters. Four and five-letter anagrams took longer to solve than three-letter anagrams, but solution time distributions were almost identical for six, seven, and eight-letter anagrams. If subjects were just randomly rearranging letters, the solution time should increase with each additional letter. Because solution time did not continue to rise, subjects must have been performing more than random letter rearrangements to find the solutions.

To account for the slower increase in time to solve anagrams as length increased beyond six letters, Kaplan and Carvellas proposed that subjects did not randomly rearrange the letters until a solution was recognized. Instead, Kaplan and Carvellas suggested that subjects looked for clusters of letters that formed common patterns in words, for example, prefixes and suffixes, since longer words are likely to contain suffixes and prefixes. Once the prefixes and suffixes are determined, there are fewer remaining letters to rearrange. If these prefixes and suffixes are separated from the anagram, the

number of different letter arrangements decreases. The letter patterns of prefixes and suffices act as cues to activating and retrieving words with the same patterns. For example, the 10-letter anagram ***AEIIGLNPRV*** can be shortened and made easier to solve by finding the prefixes and suffixes. The prefix 'pre' and the suffix 'ing' can be removed from the anagram leaving the letters ***AILV***. Once these letters are rearranged, discovery of the solution word PREVAILING is facilitated. First finding the prefix 'pre' and the suffix 'ary' can decrease the thirteen-letter anagram AAEIOUCNPRRTY. By placing these six letters in their pattern, only seven letters remain. Within those seven letters, ***AIOUCNT***, another suffix can be identified, 'tion'. By placing these four letters together, only three letters, ***AUC***, remain to be arranged to form the solution word, PRECAUTIONARY.

Letter patterns, such as prefixes and suffixes, reduce the number of arrangements. The results from Kaplan and Carvellas lead to the conclusion that anagrams are not solved simply by random rearrangement of the letters. From an anagram, problem solvers will select a few letters that form common patterns. The letter patterns, prefixes and suffixes, are used as cues to activate related words in memory. These related words are then matched with the letter patterns in the anagram until a correct solution is discovered.

Pronunciation. Letters in an anagram can be arranged in different ways, which can lead the problem solver to "read" the anagram. Pronouncing the anagram provides auditory cues and should facilitate solution. The problem with this assumption is that the anagram may be pronounced incorrectly, which may lead to retrieving incorrect solutions.

In this instance, solving the anagram will be more difficult. Therefore, pronunciation must be considered when investigating anagrams.

Dominowski (1969) investigated the hypothesis that practicing the pronunciation of an anagram would increase the difficulty of solving the problem. Subjects in the control condition solved anagrams without pronunciation practice. Subjects in the practice condition were presented with a list of 15 anagrams and instructed to pronounce each anagram as if it were a real word. Subjects read the list of anagrams five times. After the fifth repetition of the list, subjects were instructed to solve each anagram. The pronunciation practice reduced the number of correct solutions compared to the number of correct solutions by subjects in the control condition.

Dominowski suggested that the pronunciation practice generated a familiarity with the anagram and therefore a resistance to major reorganization of the anagram. Subjects viewed the anagram as a unit, rather than as separate and rearrangable letters. As a unit, the anagram will provide for correct retrieval of words with similar pronunciation and incorrect retrieval of words with different pronunciation. For example, the anagram ***LATVI*** may activate and retrieve words containing the unit 'lat' as in 'late' or the unit 'vi' as in 'vista'. The activation of these units would not suggest the correct solution VITAL. The inability to break up the words leads to the activation and subsequent retrieval of incorrect words thereby decreasing the chances of correctly solving the anagrams.

Fink and Weisberg (1981) presented visual bigram clues to all subjects prior to each anagram. Two-thirds of the subjects were also presented with the bigram clue

aurally prior to each anagram. These subjects were instructed to pronounce the bigram once exactly as the experimenter pronounced it. All subjects were informed that the bigram was to be found at the beginning of the solution word. One-third of the subjects were also accurately informed that the pronunciation was correct and one-third were accurately informed that the pronunciation was incorrect. The experimenter did not pronounce the bigram for the final third of the subjects. After the bigram was viewed and pronounced, or viewed only, the anagram was presented to the subject to solve.

In a second study, the experimenter pronounced an anagram either correctly, with respect to the pronunciation of the solution word, or incorrectly. For example, the anagram ***LATVI*** (solution VITAL) can be pronounced "latvie" (as in lie) or "lat-vee". The subject was instructed to repeat the anagram twice exactly as it was pronounced. The subject was then shown the anagram and instructed to pronounce it a third time in the same way as previously heard, at which time, the subject attempted to solve the anagram. The results of both experiments showed that if the problem solver pronounced the syllables in the anagram "correctly" with respect to how the units are pronounced in the solution word, then the probability of solving the anagram increased. If the syllables in the anagram were pronounced "incorrectly" (that is different from the solution word), then the probability of correctly solving the anagram decreased.

Pronunciation of an anagram leads to viewing parts of the anagram as set units that are difficult to reorganize. Therefore, the activation and retrieval of words with the same pattern and pronunciation as the anagram will occur. In essence, the pronunciation of the

anagram is used as a retrieval cue. The presentation of a pronounceable anagram supplies the subject with phonological information. This information is used to activate other words in memory with the same phonological pattern. Subsequently, words are retrieved based on this information. "Incorrect" pronunciation of an anagram unit leads to the retrieval of incorrect solutions, whereas "correct" pronunciation of anagrams will increase the probability of activating and retrieving the correct solutions to the problem.

To summarize, factors within the anagram provide the solution to the anagram. The letter order and pronunciation of the anagrams are two variables affecting retrieval of anagram solutions. These variables must be controlled to ensure that the anagram itself is not cueing possible solutions. Strategies for controlling the bias of cues from the anagrams themselves include fixing the number of letters and letter order so that the anagram is unpronounceable and the letter ordering pattern of the anagram does not offer any cues. Creating unpronounceable anagrams is one way to control for effects due to pronunciation. An anagram that is unpronounceable is viewed as a complete letter string made up of separate letters. If the anagram is pronounceable, then the letter string is viewed as a complete unit. The results from past research suggest that sound cues are used to activate and retrieve anagram solutions. Although subjects will still use the letter patterns and some pronunciation of those patterns, providing subjects with unpronounceable anagrams controls for the bias of retrieving words from memory based mainly on the phonological information. By eliminating all sources of cueing within the anagram that might be used differently by good and poor spellers, we can investigate how

the cues used in the present study affect anagram solving. The use of only external cues should increase the probability of accessing correct anagram solutions.

Lexical Access, Spreading Activation and Priming

The study in this paper investigates the effect of orthographic and phonological cues and semantic cues from primes rather than from the anagram itself. Words are associated in memory by different connections. As shown in Figure 1.1. the three major connections in memory are semantic (category), orthographic (visual), and phonological (auditory). More connections can be accessed within each category. The use of primes should activate words through these connections.

Lexical access refers to the retrieval of semantic, orthographic, and phonological information of words (Neely, 1991). Retrieval occurs when an activated word is brought to the level of consciousness. Activation is not an "all or nothing" event. Some information can be partially activated while other information is fully activated. The more strongly a word is activated, the more likely it is to reach consciousness.

Stimuli can be encoded at different levels, shallow or deep, depending upon the type of processing (Craik & Lockhart, 1972). The deeper the processing, the more elaborate the representation in memory. Many models (see Chang, 1986 for review), have suggested the way information is represented in memory. For instance, Collins and Quillian suggested a model where semantic memory is in a network structure (Ashcraft, 1994). In this model, concepts are thought of as nodes and the structure of semantic memory is thought of as a network of these nodes. Each concept or node is represented

in a location in semantic memory. The nodes are linked together to code the associations. Pathways between the words are assumed to be of different lengths or strengths. Shorter pathways link high frequency or typical characteristics with each other, whereas longer pathways exist for atypical features. The shorter the pathways, the closer the concepts are related in semantic memory and the faster the sought after information will be retrieved. Through this network, spreading activation retrieves information. Concepts activate other concepts in memory along the pathways of related information.

Another approach to semantic memory combines the network approach and the idea of features. Martindale (1991) suggested that the features provide the nodes (concepts) and the network provides the pathways for associating information. The more typical the feature, the stronger the activation. Even weaker words will be activated due to the connections between these words and others along the pathways. Although both models assume that semantic memory is formed by associated words, the network model provides the pathways to elicit retrieval of these words when using primes. Instead of comparing just two concepts, the network provides many pathways containing nodes to compare.

Each word is represented in memory in association with many other words that contain orthographic and phonological information. When a word is presented, related words in memory are activated. These words then activate other words that are associated semantically, orthographically and phonologically. The activation continues to spread and connect words associated through related information. For example, the word

"apple" is semantically associated with the word "orange". Both words are associated with the concept and word "fruit". In turn, "fruit" is phonologically and orthographically associated with the word "suit". If the connections between the words do not exist, spreading activation will not occur and the related words will not be activated.

When priming a word, the cue could be used to activate specific information, such as orthographic, phonological, or semantically related words (Bourne, Dominowski, Loftus, & Healy, 1986). Presenting 'pear' as a prime will partially activate some words while fully activating other words. The semantically associated word "apple", the concept and word "fruit", and the phonologically associated words "bear", "lair", and "pare" may be activated by this prime, some more strongly than the others. Additionally, each activated word will activate other words, e.g., 'bear' may activate "animal" and "forest".

Priming and anagrams. Past research has demonstrated that semantic primes speed up the retrieval of possible solution words and improve the likelihood of finding the anagram solution (Dominowski & Ekstrand, 1967; Schuberth, Spoehr, & Haertel, 1979; White, 1988). In a study by Dominowski and Ekstrand (1967), subjects were shown a list of words, one word at a time, prior to solving anagrams. The list was presented five times in a random order. Subjects were informed that the words were either the solutions to the anagrams or were strongly associated to the anagram solutions; or the subjects were misinformed that the solutions were associated when the words were actually unrelated to the anagram solutions. Subjects provided with the solutions to the anagram had direct priming which led to solving more anagrams in a shorter time than subjects in the other

groups. When the list of words was semantically associated with the solution words, the probability of solving the anagram was higher and the solution time was shorter than when the subjects were misinformed about the word list.

The authors suggested that the words in the unrelated list activated other words that may have interfered with the retrieval of the correct anagram solutions. Directly priming the anagrams or priming with semantically associated words activated possible solutions. The activation of words prior to viewing the anagrams increased the chances of retrieving correct solutions. Semantically related words facilitated anagram solution more than did the unrelated words, because words in the lexicon were partially activated prior to the actual retrieval of possible solutions. Words previously activated by a prime may be readily available when the person is subsequently attempting to retrieve a word. The solutions to the anagrams primed by words in the unrelated list were not as readily available because the primes had activated inappropriate words.

White (1988) investigated whether semantic priming occurs without explicit instructions. In this study, subjects were asked to decide whether a letter string could be rearranged to form a real word. Nonanagrams are letter patterns in which the letters cannot be rearranged to form a real word. Nonanagrams either were or were not phonologically and orthographically similar to a word related to the prime. In the first two experiments, anagrams were related or unrelated to the prime. In the third experiment, an expectancy variable was added. The primes were made up of category labels (Animals, Body Parts, Fruit, Kitchen Equipment). Subjects were informed that two of the category

labels were likely to be followed by anagrams where the solutions were from that particular category (Animal-***PGI***-PIG). Subjects were also informed that two different category labels were likely to be followed by anagrams whose solutions were from a different category (Kitchen Equipment-***AMR***-ARM). To further clarify, four conditions were created. In the first condition, solutions were related to the prime and expected by the subject. Subjects were presented with the category animal and expected to see an anagram whose solution was related to that category, e.g., CAT. In the second condition, solutions were related to the prime but not expected by the subject. Subjects were presented with the category Kitchen Equipment and expected to see an anagram whose solution was from the category Body Parts. Instead, the solution was related to the prime, e.g., SPOON. In the third condition, the solutions were unrelated to the prime and expected by the subject. Subjects were presented with the category Kitchen Equipment and expected to see an anagram whose solution was from the category Body Parts, e.g., LEG. In the final condition, the solutions were unrelated to the prime and unexpected by the subject. Subjects were presented with the category Animal and expected to view an anagram whose solution was from the same category. Instead, the solution was from a different category, e.g., APPLE.

Related, as compared to unrelated primes, decreased the number of errors when the subject was deciding whether the letter string could be rearranged into a real word. Related primes, as compared to unrelated primes, also produced faster recognition of both anagrams and nonanagrams, but anagrams were recognized faster than nonanagrams.

When the anagram solutions were from an expected category, reaction times were faster than when the anagram solutions were from an unexpected category. Unexpected target words increased the time to judge the letter string as an anagram. This was likely due to the influence of activation of inappropriate possible solutions. For example, the presentation of the prime "ANIMALS" activated words within that category ('cat', 'dog', 'pig'). When the anagram ***AELPP*** appeared, the previously activated words interfered with the retrieval of the correct solution APPLE. In contrast, the expected primes activated words within that category. When the anagram ***PGI*** appeared, the previously activated words were strengthened and PIG was easily retrieved. Semantic priming increased the probability of making a correct decision by activating words within the same category and increasing the ease of retrieving possible solutions.

Spelling Ability

Spelling patterns contain both orthographic and phonological information. Once this information is activated, it is used in both written and spoken word recognition (Perin, 1983). For example, the letter pattern 'ing' is often found in English words. If this pattern is known, associating words with the same pattern should be easy (e.g., 'sing', 'ring'). If a letter pattern is not easily recognized, associating words with the same pattern should be difficult. Knowledge of spelling patterns is necessary when solving anagrams due to requiring the rearrangement of letters. Therefore, spelling ability is predicted to be a major factor involved in anagrams in that anagrams should be more difficult for poor spellers, even for university students.

In a study of university students by Penney, C.G., Hann, P., Power, B., & Rumbolt, R. (1996), good and poor spellers were asked to retrieve words after presentation of a semantic category, a visual letter pattern, or an auditory pattern. In the semantic condition, subjects were given a semantic category (e.g., name things you wear) and asked to produce words within that category (e.g., shoes, jeans). In the visual condition, subjects saw a letter pattern (e.g., "ill") and were asked to produce words with the same letter pattern (e.g., "fill"). In the auditory condition, subjects heard part of a word (e.g., /awn/) and were asked to produce words with the same sound pattern (e.g., "brown"). University students who were poor spellers were found to have more difficulties with the visual and auditory conditions than good spellers. Students with poor spelling ability also had more difficulty than good spellers with the semantic condition, but the difference was less pronounced in this condition.

In the auditory condition, good spellers were able to generate words with ease. This implied that sound was one basis of organizing information. Rhyming words appeared to be strongly associated in the good spellers, but not in the poor spellers who had difficulty producing rhyming words. The connections between the words were either weak or absent. In the visual condition, poor spellers had difficulty retrieving words with the same letter pattern. This suggested that they might have difficulty generating, developing, or using orthographic representations. Another explanation is that university students may not have known the spelling of certain words, although this is unlikely. These results implied that letter string patterns and sounds of words are processed

differently by good and poor spellers.

The use of rhyme cues for anagram solving should interact with spelling ability due to the connections between words containing similar orthographic and phonological information. The Penney et al. (1996) study suggested that the associations between words with similar orthographic and rhyme information are either weak or do not exist in poor spellers. Consequently, rhyme cues for anagram solutions will not be effective for poor spellers. On the other hand, the connections between words with orthographic and rhyme information are stronger for good spellers. The use of rhyme cues should activate words with the same orthographic and phonological information during the memory task. This type of cue is predicted to activate words that will be available for retrieval during the anagram task for good spellers, but not for the poor spellers.

Present Study

The interaction between spelling ability and effectiveness of different cues on solving anagrams has not yet been experimentally investigated. Consequently, the present study examined the effectiveness of semantic and rhyme cues for priming solution words in an anagram task for good and poor spellers in university. Associating words with the anagram should enable the researchers to discern how particular primes affect subjects of varying spelling ability. Previous data suggest that not only should priming increase the chances of solving anagrams, but also that these primes will facilitate anagram solutions more for good spellers than for poor spellers. Many young adults, continuing their education in university, display prominent spelling problems (Bryant, MacLean, Bradley,

& Crossland, 1990; Fischer, Shankweiler, & Liberman, 1985; Holmes & Ng, 1993; Penney et. al., 1996; Rumbolt, 1994; Stuart & Masterson, 1992). Given this information, university students were studied for their ability to solve anagrams.

An initial anagram test was given to university students. Good and poor spellers were presented with up to 56 anagrams or until they had failed to solve 15 problems. Once 15 anagrams were missed, subjects were given a serial learning task. Words in the memory list were related phonetically and orthographically, semantically, or were unrelated to the previously missed anagrams. The unrelated words in the memory list act as a baseline condition to examine the effect of the semantic and rhyme primes on anagram solution. The rhyme and semantic words were expected to activate anagram solutions and increase the probability of solving the anagrams. Subjects were not informed of the relationship between the memory list words and the missed anagrams. Following the serial recall task, subjects were tested again on their ability to solve the previously missed anagrams.

According to Dominowski and Ekstrand (1967) and White (1988), the use of semantic primes activates words within the same category. This activation leads to the retrieval of possible solutions when attempting to solve anagrams. If ***IECMN*** is the anagram, the prior activation of MINCE will make it more likely to be accessed as the solution. If the word 'chop' appears in the memory list, MINCE is expected to be one of the words activated. Upon the second presentation of the anagram ***IECMN***, CHOP will be retrieved more easily due to the previous activation during the memory list. Penney, et.

al. (1996) found the connections between words within a category existed for both good and poor spellers at the university level, although a small difference occurred between the two spelling groups. Therefore, it was predicted that both good and poor spellers would benefit from semantic cues. Semantic cues, relative to the unrelated cues, should increase the probability of correctly solving the anagrams due to the activation and retrieval of words related to the primes.

The rhyme hints were predicted to increase the probability of correctly solving the anagrams in the post-test due to the activation of other words in memory with similar orthographic and phonological information. The rhyme cue "SINCE" is expected to activate orthographic information during the memory task that facilitates retrieval of the solution word MINCE along with other words in memory with the 'ince' rhyme. When solving the anagrams on the post-test, only good spellers were expected to benefit from the rhyme cues. These results were expected because associations between rhyming and similarly spelled items have been found to be weaker in poor spellers than in good spellers.

Method

Materials. A list of 56 anagram words was selected from Edwards (1985), Murray and Mastronardi (1975), Olson and Schwartz (1967), Srinivas and Roediger (1990), and Tresselt and Mayzner (1966). All anagram solution words contained five letters, had only one solution, had no repeated letters, were singular, and if verbs, were in the present tense. The anagrams were created by placing all of the vowels in alphabetical order followed by all of the consonants in alphabetical order (e.g., the solution word ABHOR appeared in anagram form as ***AOBHR***). These anagrams formed an unpronounceable letter pattern.

Each anagram solution was matched with three cue words (see Appendix A). One of the cue words was semantically related to the anagram solution, a second cue word rhymed and had the same spelling pattern as the anagram solution, while the third cue word had no relation to the anagram solution. For example, for the anagram solution BEACH, the semantically related word was "SAND", the rhyming word was "REACH", and the unrelated word was "MUTE". Semantically related words were chosen from Roget's Thesaurus of English Words and Phrases (Roget, 1979), whereas rhyming words were generated by changing the beginning letters of the anagram solution word (e.g., beach became reach). The memory list words for the serial recall task were drawn from these cue words (see section below).

Procedure. The computer presented all subjects with five practice anagrams to solve. Subjects could ask questions about the procedure before the actual experiment

began. Following the practice trials, anagrams were presented to each subject one at a time on a computer screen. The subject was instructed to solve each anagram as quickly as possible. The computer program allowed the subject 20 seconds to solve the problem once the anagram was presented. Subjects were instructed to state the solution to the anagram aloud and at the same time to press the right shift key. Once the subject gave a response, he or she was not allowed to change the answer. After pressing the right shift key, the subject then typed in the solution word, at which time the computer informed the subject whether or not the solution was correct. If the shift key was not pressed within 20 seconds, the computer scored the anagram as having been missed and instructed the subject to press the space bar to advance to the next anagram. This procedure continued until 15 anagrams were missed or until 56 anagrams had been presented. If fewer than 15 out of 56 anagrams were missed, the subject did not continue with the remainder of the experiment. Some of the anagram solutions in the pool of 56 items had the same spelling pattern (e.g., the solutions were LIGHT and SIGHT). The experimenter pressed a key to move on to another problem when an anagram appeared with the same solution spelling pattern as a previously missed anagram. This ensured that no two missed anagrams shared the same solution letter pattern.

After 15 anagrams were missed in the initial test, a list of 15 words to be memorized was generated from the cue words previously matched with the missed anagrams. The computer randomly selected five of the 15 missed anagrams to be primed with a semantically related cue, five of the 15 missed anagrams to be primed with a rhyme

cue, and five to be primed with an unrelated cue. For example, if the anagram ***AEBCH*** (solution BEACH) was not solved, the solution was randomly assigned to one of the three categories. If the rhyme category was chosen, the word "REACH" was one of the words in the memory list. None of the 15 words in the memory list were distractors for the other words, that is, "REACH" did not appear in the memory list as a cue for any other anagram; nor was it a solution to one of the anagrams. Subjects were not informed that the words in the memory list were cues to the anagram solutions.

After the memory list of 15 words had been generated, subjects engaged in the serial learning task. The computer randomly selected the words within each cue type (i.e., semantic, rhyme, no relation). The cue types were blocked within the list and the order in which the cues appeared to the subjects was counterbalanced. For 16 subjects, the first five words in the to-be-remembered list were semantic cues, the second five words were rhyme cues, and the last five words were unrelated cues. For another 16 subjects, the first five words in the to-be-remembered list were rhyme cues, the middle five words were unrelated cues, and the last five words were semantic cues. For the third group of 16 subjects, the first five words in the to-be-remembered list were unrelated cues, the middle five words were semantic cues, and the last five words were rhyme cues.

Prior to the memory list presentation, the experimenter instructed the subject to remember the list of 15 words in the correct order. Prior to each study trial on the memory list, brief instructions appeared on the computer screen. Each word was presented to the subject on a computer screen for two seconds and the subject repeated it

aloud. After the last word was repeated, the subject wrote down as many of the words as he or she could recall in the correct order; then the list of memory words was repeated. The procedure of viewing the list and recalling as many words as possible in the correct order was repeated until 15 minutes elapsed or until a criterion of two consecutive correct trials was achieved. Mazes were presented to the subject to fill the remaining time of the task. The mazes acted as a neutral filler task between the memory list and the second presentation of the missed anagrams. The task ensured that all subjects had the same interval of time away from the anagrams.

After the maze task, each subject was shown the anagrams he or she had missed on the first test. The presentation procedure was the same as in the initial anagram presentation except that the computer was programmed to allow subjects 60 seconds rather than 20 seconds to solve each anagram.

Following the second attempt at the anagrams, subjects were presented with the Word Attack Subtest of the Woodcock-Johnson Psychoeducational Battery (Revised) (Woodcock & Johnson, 1989; 1990) and the Test of Written Spelling (Larsen & Hammill, 1994). Standardized instructions were used for both tests. For the Word Attack Subtest, subjects read a list of pronounceable nonwords aloud and the experimenter scored the response of the subject as either correct or incorrect. During the Test of Written Spelling (TWS), the experimenter said a word, then read a sentence using the word, repeated the word, and the subject wrote the given word on the answer sheet provided. Two lists of words were read to the subject. The first list contained words with predictable spelling;

the words were spelled as they sounded (e.g., baste). The second list contained unpredictable spellings; the words were spelled differently from the way they sounded (e.g., liaison). Following this test, the subject was debriefed and all questions were answered.

Subjects. Sixty-seven undergraduate students from Memorial University of Newfoundland participated voluntarily in the study and were paid $4.75. Twelve subjects were dropped due to programming errors and seven subjects were dropped because they missed fewer than 15 anagrams in the initial test. The remaining 48 subjects were classified as good or poor spellers according to the median split on their performance on the TWS. The TWS raw scores ranged from 24 to 70 for the poor spellers and 73 to 95 for the good spellers. A raw score of 95 represents a university grade level, a raw score of 70 represents a grade level at 11.5, and a raw score of 24 represents a grade level of 2.3. Although university students were used for the present study, the scores show a wide range of spelling ability. Seven males and 17 females, with ages ranging from 18 years 0 months to 27 years 7 months, were classified as good spellers. Eleven males and 13 females with ages ranging from 18 years 0 months to 26 years 7 months were classified as poor spellers.

Results

Spelling Ability

The correlation between the TWS and the Word Attack raw scores was significant ® = 0.63, $p < .01$). Good spellers averaged 82.6 on the TWS and 26.1 on the Word Attack. Poor spellers averaged 50.6 on the TWS and 22.4 on the Word Attack. The correlation between the scores on the two tests shows that reading and spelling ability are linked. The Word Attack raw scores for the good spellers ranged from 22 to 29 (30 representing the highest possible score) and the scores for the poor spellers ranged from 16 to 27. Raw scores of 16, 22 and 27 on the Word Attack represent grade equivalencies of 3.8, 7.8, and 16.9 respectively. The median split on the Word Attack was a raw score of 24 and the median split on the TWS was a raw score of 70. Seven subjects who obtained a raw score higher than 24 on Word Attack were classified as poor spellers due to their TWS raw score being 70 or below. Three subjects who obtained a raw score below 24 on Word Attack were categorized as good spellers with a score of 76 or greater on the TWS.

Memory Task

There was a range from five to nine presentations of the word list for all subjects. Eighteen of the 48 subjects reached criterion; 13 of these were good spellers and five were poor spellers. Subjects who reached criterion took an average of seven trials before all words in the list were recalled in the correct order. Subjects not reaching criterion took an average of seven trials before time expired. Table 3.1 shows a frequency distribution of the number of trials to criterion by good and poor spellers. The five poor spellers who

reached criterion took more trials to learn the memory list in serial order than the 13 good spellers who reached criterion. The raw data of the frequency distribution on the number of trials to criterion was used to test for a difference between the good and poor spellers. Good spellers were not more likely to reach criterion than poor spellers ($\chi^2 = 1.28$, $p = 0.528$, $df = 2$). Figure 3.1 graphically shows that the 13 good spellers reached criterion on the memory task in fewer trials than the five poor spellers, but this was not significant.

As a post hoc analysis, the criterion during the memory task was made more lenient. Proportions of those subjects recalling fifteen words, regardless of serial order, were calculated and compared using a one-tailed Z-test. The results suggested that good and poor spellers did not differ significantly ($z = 1.46$, $p = .14$) in reaching this new criterion (see Table 3.2a). As a note, proportions of those subjects reaching the stricter criterion were compared using the same Z-test. As expected, significantly more good spellers reached criterion ($z = 2.36$, $p = .01$). These results suggest that a difficulty may lie in serial ordering for poor spellers.

Anagram Task

Three predictions were made for the present study. The first prediction was that good spellers would solve more anagrams than the poor spellers; the second prediction was that both semantic and rhyme cues would facilitate anagram solution in comparison to the unrelated cues. Presentation of rhyme and semantic cue words in the memory task was expected to activate words in memory related to the cue word, including the anagram

solution. Upon the second presentation of the anagram, the solution was expected to be easily retrieved due to the prior activation of the solution by the prime. The third prediction was that spelling ability would interact with type of hint. Good spellers were expected to benefit from both semantic and rhyme cues; poor spellers were expected to benefit from the semantic cues but perhaps not as much as good spellers. Priming with words having similar letter patterns to the anagram solution was expected to be less effective for poor spellers than for good spellers.

The data were analyzed with a 2 x 3 mixed ANOVA with the between-subject variable of spelling ability and the within-subject variable of cue type (semantic, rhyme, unrelated). For each cue type, the total number of anagrams correctly solved out of five on the second presentation of the anagrams was the dependent variable. The only significant effect in the ANOVA was spelling ability, $F(1, 46) = 4.20$, $p < .05$. Overall, good spellers solved more anagrams than did poor spellers. Good spellers correctly solved an average of 7.8 out of 15 anagrams and poor spellers solved an average of 6.4 out of 15 anagrams. The effect of cue type did not approach significance, $F(2, 92) = .59$, $p > .05$, with a mean of 2.4 out of five solutions for the semantic condition, 2.4 out of five for the rhyme condition and 2.2 out of five for the unrelated condition. Contrary to the prediction, there was a complete failure to find any effect of either semantic or rhyme cues (see Figure 3.2).

The main prediction was that the rhyme cues were expected to be less effective for the poor spellers than for the good spellers. Contradictory to the third prediction, no

significant interaction was found between spelling ability and word cue type, $F(2, 92) = .53$, $p > .05$. Good spellers correctly solved 2.7 out of five anagrams when presented with a semantic cue, 2.6 out of five anagrams when presented with a rhyme cue, and 2.4 out of five anagrams when presented with a unrelated cue. Poor spellers correctly solved 2.1 out of five anagrams when presented with a semantic cue, 2.2 out of five anagrams when presented with a rhyme cue and 2.1 out of five anagrams when presented with an unrelated cue. Good and poor spellers differed in their ability to solve anagrams, but cues were not effective for either group. Neither semantic nor rhyme cues helped either good spellers or poor spellers.

As an additional check on the effectiveness of the memory task as a priming manipulation, three different correlation coefficients were computed between the total number of times cue words were correctly recalled in the memory task and the total number of correctly solved anagrams for that cue type. No significant correlation was found for the semantic cues ($r = -.14$), rhyme cues ($r = .09$), or unrelated cues ($r = -.08$). The lack of correlation between the number of times cues were recalled and number of anagram solutions is consistent with the ineffectiveness of rhyme and semantic cues in solving anagrams.

Reanalysis Using Extreme Scores

The spelling ability scores of the good and poor spellers were closely associated which may have affected the findings of no differences in the main prediction. Subsequently, an analysis was performed using the top 16 good spellers and the bottom 16

poor spellers as analyzed using TWS scores. The reanalysis yielded a raw score range of 76-95 (mean = 86.5) on the TWS for the good spellers and a range of 24-52 (mean = 44.7) on the TWS for the poor spellers. The Word Attack raw scores for the good spellers ranged from 23-29 and the raw scores for the poor spellers ranged from 16-28. Eighty-one percent of the good spellers were classified as good spellers on both tests and 87% of the poor spellers were classified as poor spellers on both tests.

Reanalysis of the memory task showed that overall 11 of the 32 subjects reached the original criterion of recalling fifteen words in correct order for two consecutive trials. This consisted of 9 of the 16 good spellers and only 2 of the 16 of the poor spellers compared to the original subject population of 13 good spellers and 5 poor spellers. Proportions of all criterions during the memory task were calculated using a one-tailed Z-test (see Table 3.2b). Under the original criterion, good spellers differed significantly from poor spellers ($z = 2.62$, $p < .05$, $\alpha = .05$). Additionally, under the second criterion of recalling 15 words in any order for two trials, good spellers differed significantly from poor spellers ($z = 1.76$, $p = .04$). Good spellers were more likely to reach criterion. The largest difference between good and poor spellers appeared to be in the original criterion. Under this condition, the words in the memory list were recalled in order for two consecutive trials. When the order was taken out of the criterion, the difference lessened. As with the entire subject population, the problem may lie in a serial ordering difficulty.

The new subject population was also reanalyzed for the anagram task using the 2 x 3 mixed ANOVA. No significant differences were found for spelling ability, $F(1,30) =$

2.92, $p = .10$, cue type $F(2,60) = .18$, $p = .83$, or interaction $F(2,60) = .65$, $p = .52$. Surprisingly, no significant differences were found between good and poor spellers in the new data set. It was hypothesized that a larger difference between spelling ability would yield stronger differences in solving anagrams. The question that arises is why no differences occurred.

Discussion

The use of primes has been found to activate specific information in memory (Bourne et. al, 1986; Dominowski & Ekstrand, 1967; White, 1988). This activation could be through orthographic, phonological, or semantic associations. Such information becomes useful when attempting to solve anagrams. If a solution to an anagram is activated by a previously presented prime, then the solution has a stronger chance of being available for retrieval when the anagram is presented. Because the use of primes was believed to activate associated words in memory, semantic and rhyme primes were predicted to facilitate anagram solutions relative to unrelated cues (Dominowski & Ekstrand, 1967; Penney et al, 1996; White, 1988).

The present study examined the effect of spelling ability on anagram solution. It was assumed that the strength of the connections between the cues and the words in memory varies according to spelling ability (see Figure 1.1). The connections for phonological and orthographic information appear to be weaker in the poor spellers than in the good spellers (Penney et. al., 1996). Consequently, an interaction was predicted between spelling ability and type of hint in anagram solution. The rhyme cues, relative to the unrelated cues, were not expected to increase the probability of solving the anagrams for the poor spellers. In good spellers, the connections between associated words are strong semantically, orthographically, and phonologically. Semantic and rhyme cues were expected to facilitate anagram solution compared to unrelated cues. The use of semantic hints was expected to help all subjects, but good spellers were expected to benefit from

these cues somewhat more than poor spellers do. As predicted, good spellers solved significantly more anagrams than poor spellers did, but overall, the use of cues did not affect solving anagrams.

According to White (1988), there is an automatic spread of activation from memory words to anagram solutions. Additionally, the network model states that concepts are connected by pathways (Ashcraft, 1994). Information related to the concepts, e.g., spelling patterns and semantically associated words, exists along these pathways. These pathways are traveled until the sought out information is retrieved. Therefore, the use of primes should have aided the subject in solving the anagrams. Past research has demonstrated that priming with semantic cues increases the probability of retrieving correct anagram solutions (Dominowski & Ekstrand, 1967; White, 1988). Semantic primes activate words in memory associated with a list of words that strengthen retrieval of correct anagram solutions. The strength of the activation of possible solutions would affect retrieval of the word. The stronger the activation, the more likely retrieval would occur (Ashcraft, 1994). The only problem is that automatic activation of solutions disappears prior to re-testing (Neely, 1991). Subsequently, there are no cue effects when the anagrams are presented a second time.

The use of strategies increases the strength of activation by providing additional cues to the solution. In the present study, neither type of cue, whether rhyme or semantic, increased the likelihood of the subject solving anagrams. No facilitation was found, even for good spellers. The results demonstrated that there is no difference in the type of cue

presented to the problem solver. Subsequently, the question of interest is why no priming occurred. The instructions by Dominowski and Ekstrand (1967) and White (1988) induced strategic effects in addition to any effects due to automatic priming. Therefore, their use of primes to solve anagrams may have been influenced more by the use of strategies than by the automatic activation provided by the prime.

In contrast to Dominowski and Ekstrand (1967) and White (1988), no information about the relationship between the word list and the anagram task was provided to the subjects in the present study. Anagrams should have been solved through direct priming rather than by strategies. Though no information was presented about the relationship, priming should have been effective, unless the delay was too long for automatic priming. According to Hirshman and Durante (1992), semantic priming occurs at a subconscious level. In other words, no explicit instructions about the relationship between the prime and the target need be given to the subjects. Therefore, decisions of possible solutions were made through direct priming rather than from induction of strategies. So, why was there no effect of semantic priming?

Contrary to previous findings, and the predictions from the present study, semantic priming did not facilitate anagram solutions. Connections between words associated semantically were presumed to be functional and strong in both good and poor spellers, although the connections were thought to be slightly stronger in good spellers (Penney, et. al., 1996). Therefore, semantic cues should have increased the chances of solving the anagrams. Since the cues were memorized and recalled prior to working on the anagrams

a second time, they were assumed to activate the solutions to the anagrams. Good spellers were expected to benefit slightly more than poor spellers with the semantic cues, but the results showed that no difference occurred between the semantic and unrelated cues for subjects in either group. This result suggests that the solution words were not influenced by the memory list words during the memory task. That is, when the subjects were presented with the anagram ***AEBCH***, the semantic cue "SAND" either did not activate the solution word BEACH or the activation was not strong enough to promote later retrieval. Another possibility is that if the priming were automatic, the activation of the cue would be gone by the time the second anagram test was presented.

The anagrams used in the present study had initial weak connections to their solutions for both subject groups, which was demonstrated by the subject's inability to solve the anagram on the initial test. It was hypothesized that the primes would make the connections between the anagram and its solution stronger. The lack of priming to the solution word suggests that most of the cue words did not activate possible anagram solutions, or at least, the activation was not as strong as was assumed. One explanation for the lack of a priming effect may have been due to no spread of activation from the memory list word to the anagram solution during the memory task. As a result, the cues did not affect the anagram solution. This "weak link" or lack of association with the anagram solution may have been the reason the cue types did not differ from one another. If none of the words were being associated with possible anagram solutions, then the type of cue has little effect.

An explanation for the apparent lack of activation could be the recall strategies of the subjects. Words were being associated within the word list rather than between the word list and the anagram solutions. Following the debriefing, some subjects stated that the list was memorized by associating the words to one another. Therefore, associations were being made within the list rather than between the word list and the anagram solution. These unexpected associations of the memory list words may have impaired the effectiveness of the prime. Use of mnemonic devices may have blocked activation and retrieval of anagram solutions.

Another explanation for the lack of activation may have been due to the choice of inappropriate cues. The experimenter with use of a thesaurus chose the semantic primes. Although the cues were semantically associated to the anagram solutions, the subjects may not have had strong associations and connections for these specific words. Other words may have been more strongly associated and therefore were activated rather than the anagram solution. For example, the cue "SAND" was associated with the solution BEACH. When presented with the cue "SAND", other words such as 'water', 'rocks', and 'surf' may have been activated more than the solution word. One way to remedy this problem is to have another similar subject population create the semantic cue list.

Rhyme primes were also found to be ineffective for all subjects. When a rhyme cue is presented, words with similar sounds and similar spelling patterns should be activated and made available for retrieval. By having the subjects state the memory list words aloud, the cues provide phonological as well as orthographic information, thus

strengthening the potential to create a priming effect. Therefore, words with the same sound and spelling pattern should have been activated. If the sound associations between words exist in good and poor spellers, rhyme cues should have facilitated retrieval of solutions, especially with the repetition of the word list.

Rhyme cues should have activated words with similar sound and spelling patterns. Therefore, rhyme cues should have increased the possibility of solving the anagrams. The initial letter of the solution word changed to establish rhyme prime cues (e.g., beach - reach). Although these words rhymed with the anagram solution, the connections for these words may not have been strong. The associations between primes and words with similar orthographic and phonological information exist in memory (Adams, 1990). Once the associations are discovered, the words are activated. The stronger the word is activated, the easier the retrieval of a correct solution. Although the model (see Figure 1.1) predicts this result, the connections within memory are not constant (Adams, 1990). Rather, they are strong in some people and weak in others. Therefore, some words may have been stronger in association or the words used were not associated to the anagram solution for those subjects used in the present study. Keeping that in mind, other related words may have been activated, blocking the activation and retrieval of the correct solution.

The failure to find an effect of word cue type on anagram solution suggested that a problem occurred in the cognitive requirements of the memory task. Because no other research has presented potential primes in the form of a serial recall task, it is difficult to

state what other factors may have led to a lack of priming. The associations between the primes and the anagram solutions may not have been present or strong enough to elicit retrieval. No significant correlation was found between the cues and the correctly solved anagrams, suggesting that the anagram solutions were not primed even though the cue words were remembered.

Penney et al. (1996) found the connections between words with similar orthographic and phonological information to be weak in poor spellers, which raises the question as to whether orthographic and auditory cues create activation that will spread to other words in memory. Due to the weak connections in poor spellers and the strong connections in good spellers, priming with rhyme cues was expected to enhance the chances of solving the anagrams for the good spellers, but not for the poor spellers. Surprisingly, neither the good nor poor spellers were affected by the rhyme cues. The results from the present study showed that the rhyme cues did not facilitate anagram solution relative to the unrelated cues for either good or poor spellers. The rhyme cue either did not activate the solution word or the activation did not affect later availability during the second presentation of the anagrams. This result suggested that the relevant spelling pattern and the sound in the rhyme cues were unnoticed or not utilized automatically or strategically to solve the anagrams. When subjects were presented with the anagram ***AEBCH*** and the to-be-remembered word "REACH", it was thought that the common 'each' cluster would facilitate finding the anagram solution, BEACH.

The knowledge of common letter clusters was necessary in order to rearrange the

letters into the correct solution word. If the clusters were not recognized, it was difficult to solve the anagram and other strategies are necessary. In the present study, good and poor spellers used different strategies to solve anagrams; e.g., good spellers were observed to look for common patterns. Following testing, some subjects gave introspective accounts of how they solved the anagrams. Good spellers stated that they tended to search for frequent bigrams and trigrams in the anagram and then rearrange the remaining letters around the cluster. Some good spellers verbally stated a bigram and then placed the remaining letters around the grouping until the solution word was discovered. Once the correct letters were grouped together, the anagram was often easily solved. In contrast, poor spellers appeared to rearrange the letters in the anagram randomly, rather than selecting common letter strings and then rearranging the remaining letters around the bigram or trigram. In contrast to the good spellers, some of the poor spellers stated that they randomly moved the letters until a possible solution was found. Unfortunately, the number of subjects who described their strategies for solving the anagrams could not be calculated because not all subjects were asked about their strategies. Instead, some subjects volunteered this information after the debriefing.

A second possibility for the difference between good and poor spellers is that a problem occurs in serial ordering. It is interesting to note that poor spellers appeared to have difficulty with the serial recall task. While 54% of the good spellers reached criterion on the memory list, only 21% of poor spellers did so; fifty-six percent and 12% respectively for subjects in the extreme population. Those poor spellers reaching criterion

took more trials to remember the memory list words than the good spellers. This problem may not be with memory, but rather with recalling words in order. When the criterion was relaxed, so that only recall of the 15 words was assessed, 83% of the good spellers (81% in the extreme population) and 71% of the poor spellers (69% in the extreme population) recalled all 15 words. The extreme poor spellers had more difficulty than the poor spellers did in the original population in recalling words in order. It appears as though there is little difference in memory ability, but rather the difference may occur in serial order failure.

The serial order failure may be related to the difficulty in solving anagrams. Anagrams require the rearrangement of letters and subsequently correct letter ordering. Does this serial order difficulty in poor spellers only appear during recall? Or, does a difficulty in serial ordering exist in other cognitive requirements? For instance, is it possible that among the other cognitive requirements, correct ordering of letters in poor spellers is weaker due to this serial ordering difficulty? The current study did not set out to look into the differences between good and poor spellers in serial ordering. Nonetheless, further research should be undertaken to explore this intriguing result.

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Tables

Table 3.1. Frequency distribution of trials to criterion during memory task for good and poor spellers who reached criterion.

	Number of Trials	Observed Frequency
Good Spellers	4-5	4
	6-7	7
	8-9	2
Poor Spellers	4-5	1
	6-7	2
	8-9	2

Table 3.2a. Percentages of good and poor spellers reaching criterion in the Memory Task (original subject population).

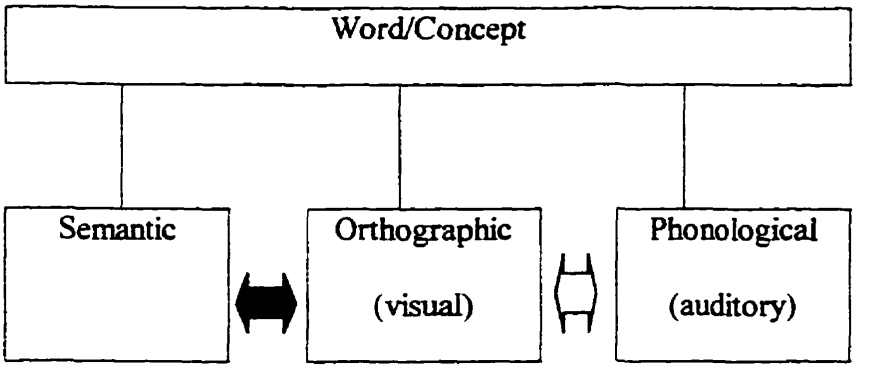
	Criterion	
	Two consecutive trials	
	Serial order	Any Order
Good Spellers	54%	58%
Poor Spellers	21%	37%
Z-test (α=.05)	z= 2.36, p=.01	z= 1.46, p=.14

Table 3.2b. Percentages of good and poor spellers reaching criterion in the Memory Task (extreme subject population).

	Criterion	
	Two consecutive trials	
	Serial order	Any Order
Good Spellers	56%	62%
Poor Spellers	12%	31%
Z-test (α=.05)	z= 2.62, p<.05	z= 1.76, p=.04

Figure 1.1. Associations between words and semantic, orthographic, and phonological information (" ⇔ " represents a weak connection).

Poor Spellers



Good Spellers

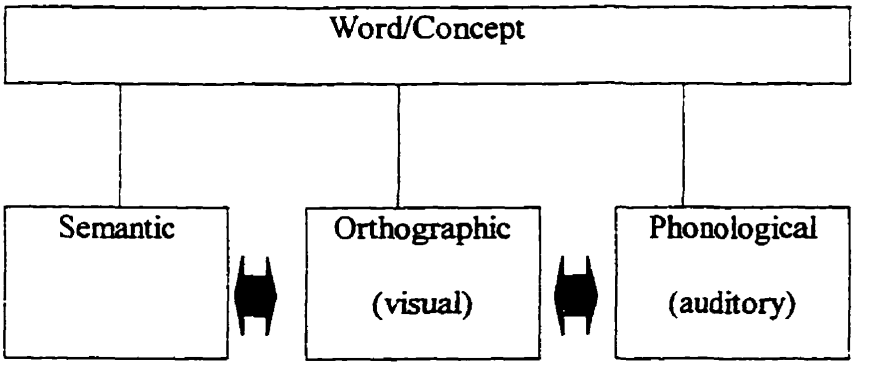


Figure 3.1: Number of trials to criterion on the Memory Task

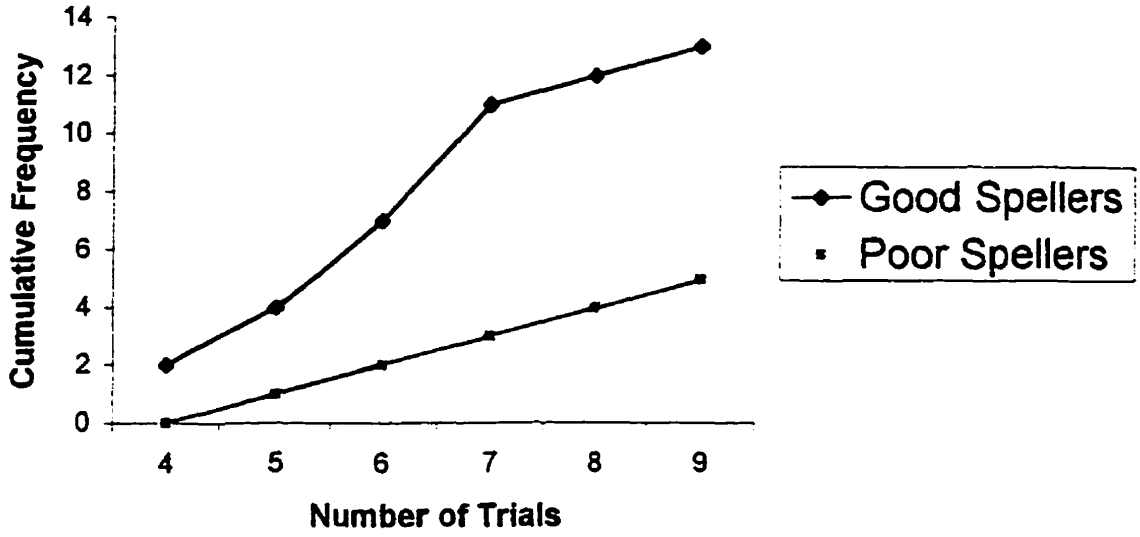
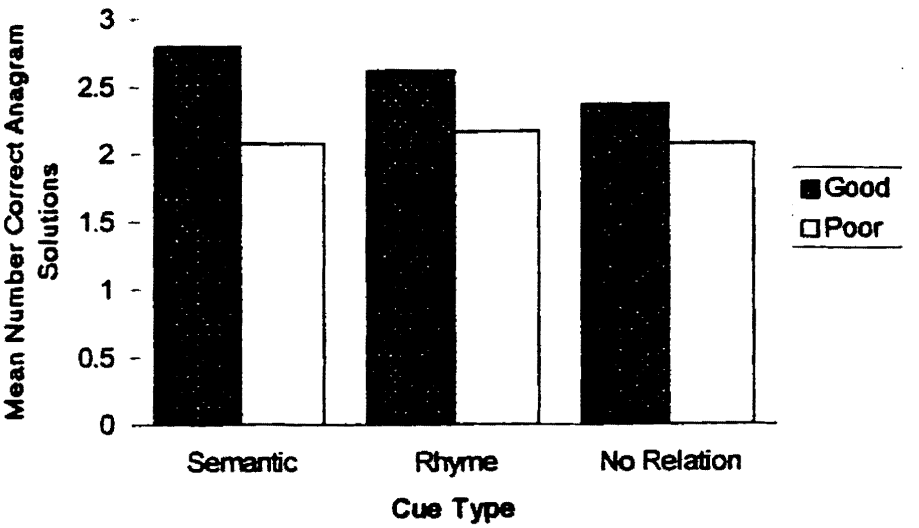


Figure 3.2. Priming effect of good and poor spellers.



Appendix A

List of anagrams, solutions and cue words. Number in parentheses represent the number of times the word appeared in the recall task.

ANAGRAM	WORD	SEMANTIC	RHYME	NO RELATION
aobhr	abhor	despise (5)	shore (2)	ride (2)
aocrt	actor	performer (7)	factor (6)	flank (10)
aeuct	acute	intense (6)	mute (8)	sketch (4)
aeoln	alone	remote (8)	bone (12)	stink (7)
aebch	beach	sand (1)	reach (2)	mute (2)
abdln	bland	dull (3)	stand (11)	lawn (7)
abkln	blank	empty (7)	flank (3)	butter (4)
ibdln	blind	sightless (3)	find (5)	halve (8)
obcht	botch	bungle (6)	scotch (9)	radio (7)
abnrw	brawn	power (3)	lawn (6)	dust (8)
ioblr	broil	cook (7)	foil (10)	crest (6)
iubdl	build	construct (6)	guild (7)	music (5)
aebcl	cable	wire (4)	table (6)	stamp (8)
aichr	chair	stool (1)	flair (0)	trust (2)
echst	chest	cabinet (5)	crest (3)	belt (0)
ocdhr	chord	music (5)	fjord (9)	vault (11)
aclmp	clamp	brace (0)	stamp (1)	rupture (1)
icgln	cling	adhere (4)	sting (10)	bake (5)
acfrt	craft	trade (3)	draft (3)	druid (5)
uchrs	crush	grind (11)	brush (11)	deck (7)
idfrt	drift	glide (10)	swift (4)	finger (5)
odnrw	drown	submerge (6)	crown (3)	frame (2)
aectx	exact	precise (4)	fact (6)	blaze (7)
aebfl	fable	story (4)	sable (3)	fashion (3)
auflt	fault	blame (0)	vault (0)	walnut (0)
aefkl	flake	peel (7)	bake (3)	below (6)
afkls	flask	bottle (9)	mask (5)	mouse (11)
ocfkl	flock	gather (3)	block (2)	lamp (2)
iudfl	fluid	juice (2)	druid (3)	desire (0)
oudfn	found	create (0)	mound (0)	ebony (0)
ocfkr	frock	dress (3)	block (3)	glisten (4)
ofnrw	frown	grimace (3)	crown (3)	snatch (5)
aeglz	glaze	cover (2)	blaze (2)	force (1)
agnrt	grant	reward (5)	slant (5)	batch (8)

ANAGRAM	WORD	SEMANTIC	RHYME	NO RELATION
iuglt	guilt	fault (1)	built (2)	horse (5)
auhnt	haunt	possess (1)	flaunt (1)	glove (1)
oudhn	hound	canine (5)	bound (1)	porch (3)
oubjm	jumbo	huge (5)	gumbo (8)	screen (6)
ighlt	light	glow (0)	might (0)	attain (0)
iecmn	mince	chop (7)	since (6)	wiper (6)
uchmn	munch	nibble (1)	lunch (6)	wander (2)
achpt	patch	repair (3)	batch (3)	dull (2)
ichpt	pitch	fling (3)	stitch (3)	crawl (1)
alnpt	plant	seed (2)	grant (1)	bungle (3)
ieprz	prize	award (0)	size (3)	thunder (0)
uchnp	punch	beat (2)	bunch (1)	trade (1)
oucst	scout	explore (9)	about (1)	rinse (8)
ighst	sight	vision (3)	might (2)	flung (0)
ikmps	skimp	scrape (5)	limp (2)	disk (4)
ignst	sting	burn (7)	fling (6)	decide (6)
ifstw	swift	brisk (7)	thrift (2)	sweet (0)
ednrt	trend	style (8)	bend (8)	book (6)
ickrt	trick	hoax (4)	brick (0)	bulky (4)
aenry	yearn	desire (9)	learn (4)	shell (10)
ougny	young	immature (4)	flung (4)	stove (4)

IMAGE EVALUATION TEST TARGET (QA-3)

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